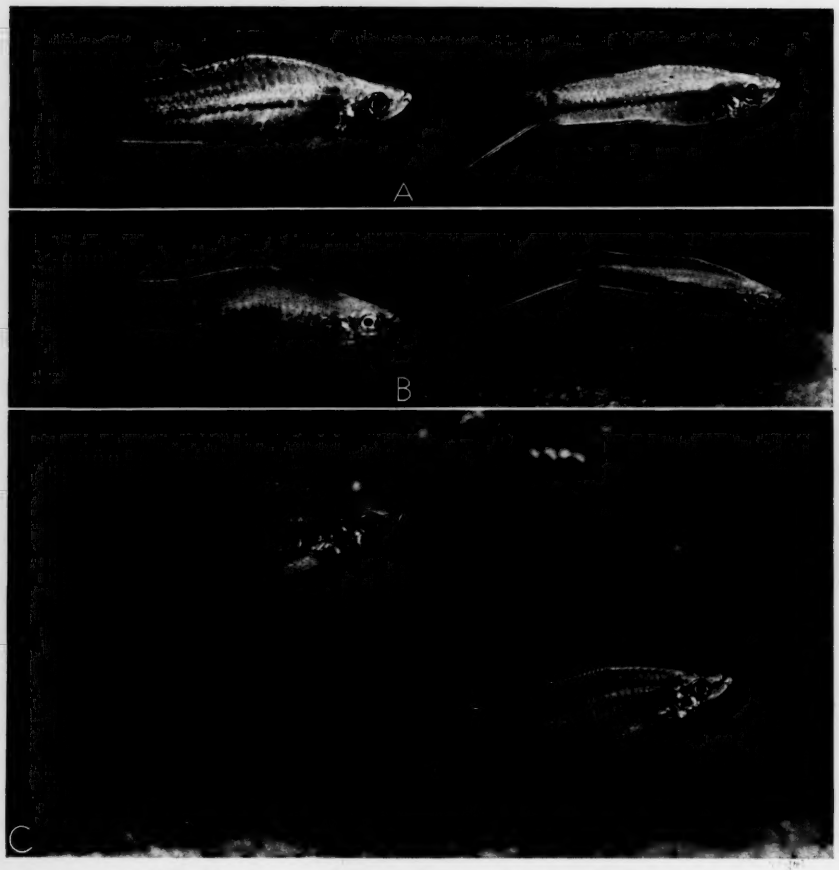
The Journal of HEREDITY



GOLD *(A)* × ALBINO *(B)* = WILD TYPE *(C)*

(SEE PAGE 385)

Induced Mutations in Neurospora

Race Crossing in Hawaii — Early Sweet Peas

Age and Hair Color — "Domestication Genes"

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VOLUME 32 NOVEMBER, 1941 NUMBER 11

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HAWAIIAN-EUROPEAN CROSSES

Frontispiece

A—Police Captain: father Hawaiian, mother half-British, half-Hawaiian. *B*—Chemist: father and mother both half-German and half-Hawaiian. *C*—Folklorist, collaborator of the Bishop Museum: father Anglo-American, mother half-Hawaiian and half-Samoan. *D*—School Teacher (Hawaiian leader): father Portuguese, mother Hawaiian.

Hawaii, since almost 150 years the center of Pacific traffic, has also become a main genetic cross-road of the world. It is unique in that a minimum of discrimination against persons of hybrid origin has been practiced: all have had virtually equal access to the advantages of the American school system, and a maximum of opportunity after graduation. The Islands thus offer an opportunity to study the biological effects of race crossing with environment more nearly homogeneous than perhaps anywhere else on earth.

RACE CROSSING IN HAWAII

A Summary of Six Years of Research

WILLIAM W. KRAUSS*

IN these days, when the eyes of the world are to a great extent turned towards the Pacific, it might be especially suitable to discuss its racial problems. In this respect, above all, the eight Hawaiian islands, located at the crossroads of the vast Pacific area and populated by different races and racial crosses, attract greatest attention.

On the basis of my six years of race-biological research in Hawaii I venture to lay before the public a short survey of some of the main results of my investigations, which will be published in full in my forthcoming books, *Races and Race Crossing in Man,* and *Race Crossing in Hawaii.*

Originally uninhabited, the Hawaiian Islands were first occupied by Polynesians, the forefathers of the present Hawaiians. Those ancient Hawaiians arrived from the South, possibly a thousand years ago and probably from the Tahitian group.

But, as various race-anatomical and cultural indications intimate, the original racial home of the Polynesians seems to have been located farther westward, somewhere southeast of Asia. Because of peculiar distribution of blood-group frequencies among the Polynesians, and because of the far-reaching deviation of their physical type from that of the Asiatic races, the author cannot regard the present Polynesians as late immigrants from the South Asiatic mainland, as some scientists believe. Rather he considers them the easternmost variant of the so-called "Europoid" group of mankind, that is, a group European-like in a broader meaning. The ancestors of the present Polynesians must have been separated many thousand years ago from their brown-skinned "Europoid" relatives in India or its neighboring countries by the mighty Mongoloid (Farther Indian and "Malayan") waves, which absorbed the original bridge of Polynesoids between those eastern Polynesians and the races which inhabited southern India.

The fact, however, that many words and constructions of Polynesian idioms resemble the most ancient known forms of the Indo-European ("Aryan") languages, might be explained in two ways: a) by the assumption that old "Aryan" loan words of the Indonesian ("Malay") language, like certain other cultural elements from India, penetrated into the Polynesian idioms as a consequence of peaceful or warlike contacts of those "Malay" peoples with the Polynesians. b) By the supposition that in early prehistoric times small "Aryan"-speaking groups from India, possibly castaways, might have amalgamated with the ancestors of the Polynesians.

For centuries the ancient Hawaiians lived in their islands practically isolated from any contact with non-Polynesians. But since the discovery of Hawaii by the British expedition under James Cook in 1778, a constant influx of foreign immigrants took place, which culminated between 1875 and 1910.

Today the total population, of about 425,000 persons, is of a very heterogeneous composition. At the time of the discovery, the Polynesian population of the islands was not over 300,000; not 400,000, as Cook overestimated. Today this is represented by only about 20,000 "pure" Hawaiian descendants. The "Haoles," i.e., the whites of mostly Anglo-American and Northwest European extraction, number some 70,000. Furthermore,

*The author was for twelve years (1922-1934) research assistant at the State Institute for Race Biology in Uppsala, Sweden, under its then director Professor Herman Lundborg. He began his research in Hawaii as a fellow of the Royal Swedish Academy of Sciences in 1935.

there are approximately 30,000 Portuguese (mostly from the Azores and Madeira, a few from the Cape Verde Islands), 1,000 Spaniards (from southern Spain), 8,000 Puerto Ricans, 30,000 Chinese, 160,000 Japanese, 7,000 Koreans, and 53,000 Filipinos. There are, in addition, 45,000 Part-Hawaiians, i.e., crosses of Hawaiians with other races (mostly with whites and Chinese), as well as a small number of crosses of whites with "Orientals," namely, with members of the above named Asiatic groups. Altogether, the population of the Islands consists of 65,000 Hawaiians and Part-Hawaiians, 250,000 Asiatics, and 110,000 "Euro-Americans" ("Haoles," Portuguese, Spaniards, and Puerto Ricans).

Hawaii as a Human Genetics Laboratory

Hawaii was chosen as a field of this research for the following reasons: Studies in these islands should be almost free from certain sources of error which in many other race-crossed countries make it difficult to determine what the consequences of race crossing itself are, uncomplicated by unfavorable racial or social selection of the parent generations or noxious environmental influences. In Hawaii the crossings have taken place between races none of which belongs in regard to intellect to the really primitive ones, and all social groups have participated in these interracial marriages. Moreover, all the parent "races" as well as the various crosses enjoy in principle equal rights to education in modern elementary and higher American schools, including the university. In other regards too, practically the whole population has been living under the strong influence of *one* culture, the American. Thus the population of Hawaii offers a material in which the effects of bodily and mental inheritance in racial crossings can be studied without being too heavily veiled by one-sided selections or by widely varying environmental influences under which the parent "races" live.

Scientists like Romanzo Adams, Andrew W. Lind, and others have studied race crossing in Hawaii mostly from the sociological viewpoint. The author's study is the first to test the methods of biological heredity research on race-crossed families of the Islands. And while others have based their studies predominantly on group behavior, this work has made the investigation of personality the main principle of its method, examining as many individuals as possible.

Ten families have been investigated: four of Hawaiian-white descent, the white being a) English-French, b) German, c) Portuguese, d) Spanish; five of East-Asiatic-white descent (Japanese-German, Japanese-Spanish, Korean-Spanish, and two Chinese-Danish); and one of Hindoo-Danish descent. Several others, e.g., a Chinese-Hawaiian and a Chinese-Hawaiian-English family, are in preparation. The families belong to different social groups, from modest plantation laborers to social leaders of the Islands. A second article soon to appear in this JOURNAL will give a detailed analysis of some of these families. In this article only the general conclusions from this study as a whole will be presented.

Further, there have been measured and photographed about 700 individuals of all social groups, both of the parent "races" and of the race-crossed population, and a collection of 3,000–4,000 negatives has been made, all carefully taken by the author in his photographic studio.* Of each individual at least four photos have been taken, namely, the three scientific norms (front, profile, half-profile) and one or more free poses showing better than the conventional norms some of the psychical expressions typical of the person. Unusually interesting persons have also been photographed in artistic poses.

In the following conclusions, the reservation is made that these findings concern Hawaii only. Thus the possibility remains that race crossing in other countries might have led to results deviating more or less from those reported here.

*The pictures of the Frontispiece and Figures 1-2 belong to this collection.

Conclusions

On the basis of the above mentioned methodical investigations and the author's prolonged personal experience with numerous members of each racial and social group in Hawaii, *twelve main statements* may be made:

1. In any study of race crossing, much more attention than heretofore must be paid to the very great *bodily and mental variability of each parent race,* which conditions a corresponding *high variability of the crosses.* The individuality of the cross is not the result of the mating of racial averages, but is conditioned by the personal hereditary dispositions of the parent individuals, who can, within the same race, deviate from each other very considerably. Hereto are added the material and mental influences of environment which, though incapable of changing the hereditary dispositions of the cross, can at any rate promote, or prevent, their development within certain fixed limits.

2. To find out which characteristics are *dominant* (perceptible) and which *recessive* (imperceptible) in inheritance, is by no means so easy as the layman usually believes. Here too the variability of each characteristic plays a considerable part, and different variants of the same characteristic may appear in the hybrid in varying degrees. This has been observed especially in the inheritance of variants of the so-called Mongolian fold (upper eyelid fold).

It cannot be said that one race type as a whole is more dominant than another. The eye of the layman perceives only the appearance of certain parental characteristics (e. g., the colors of a dark-pigmented race) in the hybrid more easily than other characteristics which become evident only to the trained eye or by the measurements of the expert.

The influence of the individual types of the parents on that of the cross may be learned, for instance, from a comparison of four persons, all of whom are half-"Oriental." While the persons of Figure 1*D* and Figure 2*D* show the characteristics of the Mongoloid race group fairly clearly, such characteristics are not very perceptible in the persons of Figures 2*B* and 2*C*, whose Asiatic parents are long-faced and lack the prominent cheek bones associated in our minds with the "Oriental" physiognomy. Of course, the type of the non-Mongoloid parent also plays a role in such crosses. Such instances make it clear that human race hybrids can rarely be comparable to crosses between the purified strains used in the genetic laboratory.

3. Though in Hawaii — as everywhere else in the world—human couples hardly have enough children to prove the validity of the *Mendelian Laws* by exact figures, phenomena of inheritance according to these laws can be shown fairly distinctly among the crosses.

It is, however, most difficult to show the phenomena of the First Mendelian Law, i.e., of the Law of Uniformity, which says that the F_1 crosses of one and the same couple, in which each partner belongs to different pure races, are identical among themselves. According to the observations of the author, such human crosses are fairly identical in a few racial characteristics only, but can differ from each other in other racial characteristics very considerably. In the above named German-Japanese family, for instance, of which both parents and nine adult children (six sons, three daughters) were examined, all the children resemble each other in pigmentation of skin, hair and eyes as well as in stature and nose form (more or less intermediate between the parents), but show a considerable variability of the Mongolian fold as well as of face form and of the prominence of the cheek bones, from an almost "Oriental"-looking son to almost "European"-looking children, as, e.g., the son, Figure 2*B*. The three daughters too show in regard to these characteristics a certain variability, though it is not quite as great as among the six sons. The reason for this variability of the F_1 crosses of the same family may be that both parents possess most of their characteristics on a heterogeneous basis, or, expressed in more popular terms, that among the ancestors

HAWAIIAN-ORIENTAL CROSSES

Figure 1

A—Superintendent of Buildings in the City and County of Honolulu: father Chinese, mother Hawaiian. *B*—Officer in Social Service and Folklorist: father half-Japanese and half-Hawaiian, mother half-German and half-Hawaiian. *C*—Student of a commercial school: father Chinese, mother half-Chinese, half-Hawaiian. *D*—High School Student:: father Filipino, mother half-Portuguese and half-Hawaiian. Segregation for a number of racial traits can be noticed in the various generations of crosses as observed in Hawaii.

of each parent there are many different variants of the race concerned.

It is much easier to show the validity of the Second Mendelian Law, i.e., the Law of Segregation, according to which in a family in which both parents represent crosses of the same races some of the children may be similar to the parents, while of the rest of the children some may resemble more the one and some more the other of the races of the grandparents. This phenomenon has been observed with special clearness in a family in which both parents are half-European (German) and half-Hawaiian and in which, besides the parents, all the eleven adult children (four sons, seven daughters) were examined. The sons look more European than Hawaiian (Frontispiece *B*, for instance, represents one of these sons). Of the daughters, one looks so European that Hawaiian characteristics hardly can be traced in her; in the others, however, the Hawaiian component is distinctly recognizable in varying degrees.

According to the same Law of Segregation, the probability that crosses resemble in most characteristics one of the races of the grandparents becomes, of course, particularly great in cases where one parent is a cross between two races and the other parent a pure member of one of these two races, i.e., in cases where marriage of the parents represents a backcross of an F_1 hybrid to one of the parent races. Examples for such a predominance of one race of the grandparents in the cross are given in Frontispiece *A* and in Figure 1*C*. The former looks predominantly Polynesian; the latter, predominantly oriental.

In some families, the children of a European and a supposedly pure Hawaiian look much more European than in others. This may be due to an unrecorded admixture of European blood among the ancestors of the "pure" Hawaiian.

The Third Mendelian Law, i.e., the law of Independent Assortment, according to which the single hereditary factors are usually inherited independently of each other, can frequently be observed.

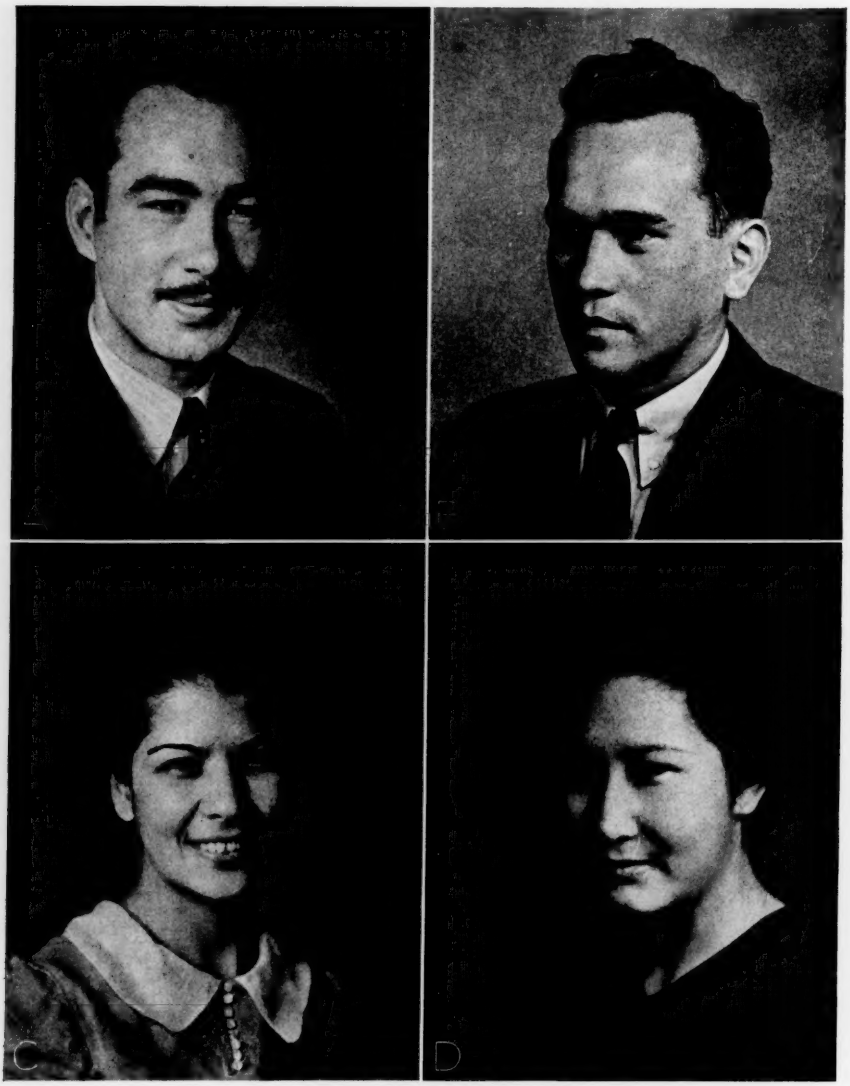
4. The conception that race crossing in man, because of "probable" *difficulties of the hereditary dispositions from the parent races to collaborate with each other,* should produce bodily or mental disproportions, greater susceptibility to certain diseases or any other defects of the hybrid, *can by no means be verified in Hawaii.* This is true whether crosses of two or of several races are involved. No increase of hereditary disturbances which might be attributable to the mere biological fact of race crossing has been noticed by the author nor by any physician or other scientist working in the Islands. Thus no indication has been found in Hawaii that race crossing should have produced an unusual number of individuals with disproportionate trunk or limbs, or with too small teeth in too big jaws or too big teeth in too small jaws, or with extraordinary elongation of the face. And among the crosses no higher percentage of "unbalanced" characters, whose instability could be explained by some disturbance in the mechanism of heredity, has been found than among the parent races.

We may emphasize that some particular speculations concerning certain noxious biological effects of race crossing in man, which older scientists are inclined to assume, could not be verified:

No indications have been discovered that in couples where marriage partners of different race by chance have different blood groups (this need not necessarily be the case) the progeny must be in some way inferior to the parent individuals "because of a non-fitting of the different blood groups to each other." Nor could any facts be stated which would support the fears that race crossing in man leads to an unusual increase of bodily or mentally intersexual individuals. The basis for such a fear is that intersexes are found in certain species hybrids, but these differ from each other much more than human races do.

No evidence was found to support the conjecture that differences in body form between the mother and her child from a father of other race should cause difficulties in birth.

In correspondence with scientists, how-



ORIENTAL-EUROPEAN CROSSES

Figure 2

A—Tax official: father Norwegian, mother half-Chinese, one-quarter English and one-quarter Hawaiian. *B*—Clerk: father German, mother Japanese. *C*—Housewife: father Korean, mother Spanish. *D*—Stenographer: father Korean, mother Portuguese. Neither marked "hybrid vigor" nor evidences of "degeneracy" are to be found among the hybrid population of Hawaii.

ever, who have critically studied the birth rate of race crossed populations of Hawaii or other countries, no evidence could be found of sterility due to racial incompatibilities. This was true of couples where the partners belonged to different "pure" races as well as in cases where one or both of the partners were crosses themselves. As far as the author was able to discover, no reduction of reproductive capacity could be found which could be suspected to be the biological consequence of race crossing, e.g., of incompatibilities between the gametes of different races. The birth rate in such hybrid families seemed to be proportionate to the extent to which these had come under the influence of voluntary birth control.

5. True *"hybrid vigor"* ("Luxurieren") like that observed in species crosses and in hybrids between closely inbred stocks of plants or animals, according to which the crosses, because of the removal of certain noxious effects of inbreeding, are much taller or stronger, or more highly talented, than the average of the parent stocks, has not been found in the race-mixed population of Hawaii. Certainly, remarkable vigor occurs in some of the race-crossed families, but in such cases usually one or both of the parents exceed by their bodily or mental hereditary dispositions the mean levels of their racial groups. Hence we may assume that the apparent "hybrid vigor" is not conditioned by any particular process of hybridization proper, but is due merely to the very common appearance of above-average variants in the sense of the Mendelian Laws, as it often occurs also in families in which both parents are of one and the same race. In some cases where race-crossed children exceed their parents in stature or muscular strength, this can be explained simply by environmental effects of nurture and other hygienic influences. These, in modern Hawaii, where these crosses were raised, favor bodily development in certain respects more than those of the time and countries in which the parent generations of the crosses grew up. The some phenomenon is observed elsewhere, notably in the increases in stature of children over parents in the continental United States.

Nor can we observe in Hawaii the opposite of "hybrid vigor", namely, true bodily or mental *"pauperism."* Where a similar phenomenon occurs, it more probably is due merely to a biologically unfavorable selection of the parent individuals, or to especially detrimental influences of environment, i.e., to influences of selection and environment opposite to those effective in the previously mentioned pseudo-hybrid vigor.

6. In spite of the frequent assertions of superficial observers, there is not a new "mixed race" arising in Hawaii. Nevertheless, it is true that the number of crosses between Hawaiians, "whites" and Mongoloid Asiatics is constantly increasing in the Islands. If the present conditions of racial intermarriage continue, among the hybrids those will probably be most numerous who—though not forming one narrowly limited "mixed type"—will unite in themselves characteristics of all the three racial parent groups. However, because of the constant new admixture of "white" and Asiatic blood to the racial group of the Part-Hawaiians, most of the individuals of this group will in the future show less Hawaiian, but more "white" and Asiatic characteristics than at present.

7. For the supposition that race crossing stimulates mutation, i.e, brings about new hereditary dispositions which would not have yet existed in the parent races, no indication can be found in Hawaii. But through new combinations of the characteristics from the various parent races, *new forms of mankind* have arisen.

8. Concerning the *inheritance of intelligence,* the following may be stressed here. Mental differences between races are not absolute, i.e., so far as we know, there are no basic elements of feeling and thinking which would occur in one or a few races only, and not in others. But races deviate from each other by different frequencies of higher or lower degrees of the same mental qualities. If individuals of race *A,* which contains a great percentage of persons with high degrees of a certain hereditary disposi-

tion (e.g., for rhythm), marry persons of race *B*, in which individuals with the same high degree of the same quality as in race *A* are rare, then in most of the cases more highly gifted persons from race *A* meet less gifted persons from race *B* and are likely to produce persons with a talent between those of the parent races. But there are also cases thinkable, where persons from the least gifted strata of *A* and *B* marry and produce hybrids below the average level of the two races. And on the other hand, cases are also possible where persons from the most gifted groups of the races *A* and *B* marry and produce crosses superior (as regards the talent concerned) to the mean levels of the parent races. These three groups of mental results can all be observed in Hawaii.

The great majority of the racial crosses of Hawaii certainly occupy modest social positions. Nevertheless, a not inconsiderable number of "white"-Hawaiian, Chinese-Hawaiian, and "white"-Chinese-Hawaiian crosses have been very successful in public administrative and educational work (e.g., the persons, Frontispiece *A-D*; Figure 1 *A*, *B*; Figure 2 *A*). The same, so far as we may conclude from a small number of cases, might also become true in the future for crosses of other Asiatics (e.g., Japanese) with Hawaiians, and for certain Asiatic-"white" crosses.

9. In respect to *moral behavior*, which is to a high extent capable of being influenced by environment, we can say that, given a suitable education at home and in school, the crosses do not in general show behavior inferior to those of similarly trained persons of their parent races. Thus, the facile phrase of the general "moral inferiority" of human hybrids finds no support in Hawaii.

10. It is remarkable that in many race-crossed families the *cultural influence of the foreign parent nationalities* upon the children is very weak or even insignificant, while it is American civilization which models the main features of the character of the hybrid. It may be especially pointed out that the crosses of the Islands have proved, both in peace and war, to be excellent American patriots, warmly attached to their native country, Hawaii. The crossings in these islands are certainly not giving rise to a new race, but are producing a new population, by descent Polynesian, European and Asiatic — by culture American.

11. A general judgment should never be based upon the assumption that crossings between groups from two different races must in all cases have the same result. This fallacy has frequently appeared in discussions of human race crosses. Thus the uniform F_1 obtained in the genetics laboratory when artificially purified strains are crossed has no valid parallel to what results when the highly heterozygous members of two human races are crossed.

It is essential to examine carefully in each case what selections from those races have participated in the crossings, as well as the environmental influences under which the crossed population has been living.

The single hybrid, however, has to be evaluated on the principle: *Personality takes precedence of race.*

12. The *problem whether race crossing is desirable* for the benefit of a whole people or not may be solved in various parts of the world in different ways, according to the bodily and mental qualities of the racial groups involved, and to the particular biological and social needs of each country.

As a *final general conclusion* it may be emphasized:

The population of Hawaii offers a picture of biological and social contacts between various races and peoples such as large areas of the world will probably present in centuries to come.

In many countries the solution of racial problems has presented the greatest difficulties. In Hawaii, however, the American government has done admirable work in preventing threatened interracial conflicts in the simplest and most magnanimous manner, by giving all races a fair deal.

The crosses in Hawaii have a great task to fulfil: to form a binding link between the parent races, and to become, in a broader sense, mediators between the Old and the New Worlds.

INHERITANCE OF EARLINESS OF FLOWERING IN THE SWEET PEA

THOMAS M. LITTLE* AND JEROME H. KANTOR

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THE first variety of early- or winter-flowering sweet pea (*Lathyrus odoratus*) was introduced in 1889, and was called "Blanche Ferry." According to a report in the *American Florist* in 1898†, the wife of a quarryman in northern New York found, about 1858, a bright flowered plant in the variety "Painted Lady." She saved the seeds from this plant and continued to select the best plants over a period of 25 years. It was her claim that the plants became more compact and sturdy with each succeeding generation. About the year 1883 she sold 100 seeds to D. M. Ferry and Co., who introduced the variety in 1889. Florists soon started growing this variety in greenhouses on account of its winter-blooming habit. In 1892, a still earlier strain was introduced, known as "Extra-Early Blanche Ferry." During the same year Zvolanek found an early "sport" in the variety "Lottie Eckford," which he crossed with "Blanche Ferry" to produce "Christmas Pink," which was introduced in 1898. In 1893 Peter Henderson and Co. introduced "Emily Henderson" which was a "sport" out of "Blanche Ferry." In 1898 W. Atlee Burpee Co. introduced "Earliest of All," which was even earlier than "Extra-Early Blanche Ferry" and was selected from that variety. In 1900 the Telemy group of early sweet peas appeared from Algeria where they were developed by Theodore Arkwright from selections out of "Blanche Ferry." Also in the year 1900, an early variety appeared from Germany known as "Mont Blanc." In 1903, still another group of early varieties appeared from England, known as the Englemann group, since they arose from an early plant found in "Captain of the Blues" by Englemann. In 1904, "Extreme Early, Earliest of All" was introduced by Burpee. This variety was selected out of "Earliest of All." Another especially early-flowering variety was introduced by Burpee in the same year, known as "Earliest Sunbeams."

Soon after the introduction of "Countess Spencer," the early varieties were crossed with the Spencers and the first Early Spencer was introduced in 1912. Many other varieties of Early Spencers followed in rapid succession so that soon a complete range of colors was available in this type and completely replaced the older "grandiflora" type. About 1910 an early mutation occurred in a Spencer variety in Australia which gave rise to the variety "Yarrawa" introduced in 1915.

From the preceding history, it would appear that the early-flowering mutation in sweet peas occurred several times in various parts of the world, and that the present-day early-flowering strains did not come about as a result of a single mutation, but as the result of a series of changes, each one increasingly earlier.

The early- or winter-flowering sweet peas exclusively are used by florists for greenhouse culture. They are also adapted for garden use in the Southern States where the winters are mild. The late- or summer-flowering type is adapted for garden use in the Northern States. It is rather odd that in spite of the importance of this character in the culture of

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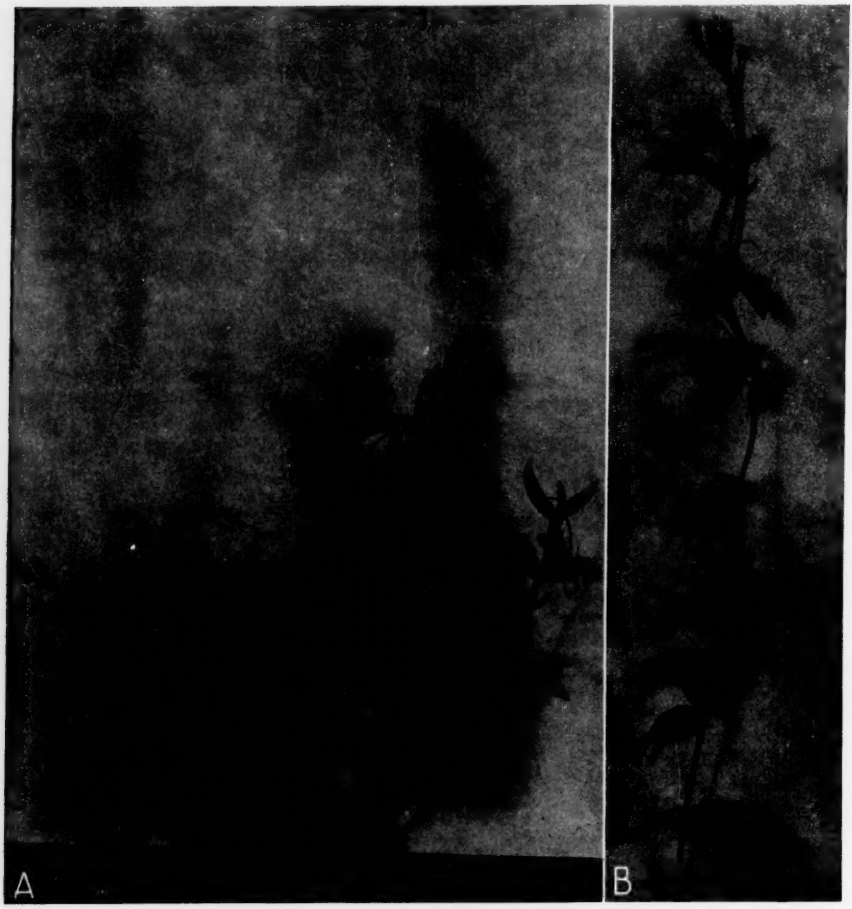

LATE- AND EARLY-FLOWERING SEEDLINGS
Figure 3

A—Young seedling of late-flowering sweet pea showing large lateral branches which appear during the early stages of growth. These remain prostrate during early development, and grow upright at flowering time. *B*—Young seedling of early-flowering sweet pea showing the absence of lateral branches during the early stages of growth. Flowers appear on the single stem when it reaches a height of two or three feet.

sweet peas, it has never been investigated by geneticists. This is probably due to the fact that most genetic research on sweet peas has been carried out in England, where the early-flowering type is very seldom grown.

The earliest work done on the genetics of sweet peas was by Bateson, Saunders, and Punnett. In 1927, Punnett published a monograph on the genetics of *Lathyrus odoratus*. This monograph gave an analysis of 18 hereditary factors but did not include the "early" character.

The present paper is the result of a study on the genetics of earliness, based on the records of eight generations.

Material and Methods

In order to determine the method of inheritance of earliness in sweet peas, we have traced the pedigrees of all of the descendants from a cross made between a late and an early sweet pea in 1933. This pedigree includes 474 populations.

In the sweet pea the pollen is shed by the anthers before the flowers open, so that self fertilization usually occurs before foreign pollen can reach the pistil. Fleming has reported a case of natural crossing in sweet peas, and our own observations indicate that occasional cross-pollination does occur, but this is so rare that no protection is needed to prevent outside pollination. In crossing sweet peas, the anthers must be removed from the small buds by splitting the keel and pulling off the anthers with tweezers. To prevent contamination in the exposed flower, the flower and stem are enclosed with cheesecloth. The flower can be pollinated immediately after emasculation, but a better "set" of seed may be obtained if a day or two elapse between emasculation and pollination.

Description of the "Early" Character

In normal late-flowering sweet peas the rate of growth in the early stages is slow, and several laterals are produced which form a low prostrate mat in the young plants (Figure 3*A*). After these laterals are well developed, they grow erect and produce flowers. The early- or winter-flowering sweet peas on the other hand, assume an erect growth from the beginning (Figure 3*B*) and produce few laterals. These start flowering as soon as they reach a height of two to three feet. The difference between the two types is not only one of habit, but also one of photoperiodic response. The late-flowering type requires a day-length of about 15 hours to bloom, while the early-flowering type will come into bloom during the short days of mid-winter. Experiments have shown that by increasing the day-length to 15 hours with artificial light, the late-flowering type can be forced into bloom during the winter time. When both types are planted in January in the vicinity of Lompoc, California, there is about one month's difference in blooming time between the earlies and the lates.

Results

Homozygous Lates × *Homozygous Earlies*

In 1933 a cross was made between a

Table I. Late-Early Segregations in Progenies from Selfed Heterozygous Late-Flowering Plants

Pedigree	Lates	Earlies	Total
L-35-38	108	34	142
L-36-38	72	25	107
L-48-38	45	15	60
L-49-38	73	31	104
L-50-38	65	19	84
L-51-38	73	19	92
L-52-38	83	28	111
L-53-38	69	16	85
L-140-38	29	17	46
X-46A-40	16	3	19
X-46B-40	82	30	112
Totals	715	237	952
Expected 3:1	714	238	
Deviation	1		

Table II. Early-Late Segregations--Backcrosses of Heterozygous Lates x Homozygous Earlies

Pedigree	Lates	Earlies	Total
X-8-38	15	18	33
X-10-39	19	8	27
X-11-39	10	13	23
X-12-39	2	2	4
X-13-39	1	1	2
X-14-39	4	6	10
X-15-39	4	3	7
Totals	55	51	106
Expected 1:1	53	53	
Deviation	2		

true-breeding late variety and a true-breeding early variety. The first generation from this cross contained nothing but late plants. Similar crosses in 1937 and 1938 gave the same result.

Heterozygous Lates Selfed

The late plants resulting from the late × early crosses were allowed to self in 1934, and the F_2 generation was grown in 1935. The F_2 population in 1935 consisted of about 75% lates and 25% earlies. Since then, a large number of heterozygous lates have been selfed and have always given progenies with lates and earlies in that proportion. A series of actual counts in progenies from selfed heterozygous lates was made in 1938 and 1940 (Table I). In a population of 952 plants, there was a deviation of only 1 from the 3:1 ratio.

Heterozygous Lates × Homozygous Earlies

In 1937 a late plant was crossed with an early plant and the F_1 from this cross grown the following year produced 15 lates: 18 earlies. The late plant used in the cross was selfed and gave approximately a 3:1 segregation, showing that it carried the early character. In 1938 a series of six crosses was made between heterozygous lates and homozygous earlies. The total of all F_1 populations from this type of cross (Table II) showed 55 lates: 51 earlies, a deviation of 2 from an expectation of 1:1.

Homozygous Lates × Heterozygous Lates

Several crosses of this type were made in 1937 and 1938, and F_1 populations invariably consisted of all late plants. When these populations were selfed, they gave rise to progenies whose proportion of early plants was between 10 and 15 per cent, although no precise counts were made.

Homozygous Lates × Homozygous Lates

A large number of crosses have been made between true-breeding late varieties, involving nearly all of the important varieties of late sweet peas. These have invariably given rise to F_1 generations which were all late and showed no segregation in later generations.

Homozygous Earlies × Homozygous Earlies

Likewise, nearly all of the important varieties of earlies have been intercrossed, and these invariably give rise to nothing but earlies in the first and later generations.

Discussion and Conclusions

The results of crossing lates with earlies indicate that lateness is dominant over earliness in sweet peas. Furthermore, the 3:1 segregation in the second generation indicates a monogenic difference. This is further substantiated by the back-cross ratio of 1:1 observed when heterozygous hybrids are crossed with earlies. The existence of more than one late-early factor in the varieties studied is precluded by the observations that all crosses between true-breeding standard late varieties produced only late-flowering plants in the F_1 and all succeeding generations; and all crosses between early-flowering varieties produced only early-flowering plants in the F_1 and all succeeding generations.

Although all of our observations indicate that the difference between the early- and late-flowering types of sweet peas is due to a single pair of factors, a variation in blooming time within the types shows the presence of modifying factors. Thus, there are extra-early varieties such as "Cherry Red" and "Miss Canada" that bloom one or two weeks earlier than regular early varieties. There are also some varieties that have the plant habit of the Early-Flowering type, but bloom about a week later. Among the late-flowering type, the multifloras come into bloom a week or two later than the other varieties. The presence of such modifying factors probably explains why the present day early-flowering varieties evolved through a series of steps.

Summary

The early-flowering character in sweet peas (*Lathyrus odoratus*) is recessive to late-flowering. The difference is due to a single pair of alleles.

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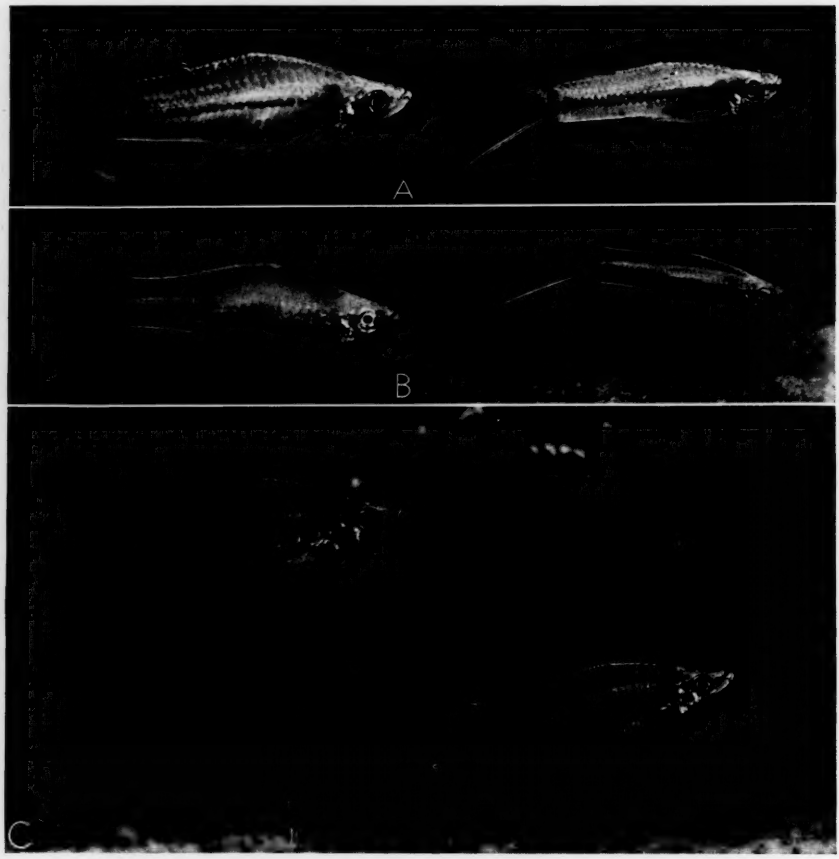
Less Males

The United States has always had more males than females. However, trends observable in the 1940 Census suggest that this situation may well disappear in the future. The ratio of males to 100 females was 101.1 in 1940, the lowest excess of males in our history, the sex ratio having continuously declined from a high of 106 in 1910. This decline is due to the cessation of foreign immigration, which has been predominantly composed of males, and to the aging of the population, which tends to reduce the proportion of males because the lengthening of life provides a longer span for the sex differences in mortality favoring females to operate.—*Population Index*, April, 1941.



REVERSION TO ANCESTRAL COLOR IN THE SWORDTAILS

Figure 4

The color of the Wild swordtails, a pair of which are shown at the bottom (*C*), with the female on the left and the male on the right, is olive-green. This ancestral coloring is really a mosaic pattern and consists of two kinds of many tiny pigment-carrying cells, the blacks and the yellows. The Golden swordtails, a pair of which are shown on the uppermost line (*A*), owe their distinctive coloration to the fact they have lost all but a few of tiny black pigment-carrying cells, but they have retained, in full force, all of their yellow cells. The Golden swordtails have normal, black eyes. The Albino swordtails, shown below the goldens (*B*), have a few yellow pigment-carrying cells but no black ones at all, not even in the retina. For this reason their eyes are pink.

The Golden and the Albino forms are true-breeding, see Figure 5. If the Gold and the Albino are crossed, the offspring are Wild-type in color pattern. This cross illustrates how "reversion" can be explained by the cooperation of genes which have become separated in the process of selection incident to the development of domesticated breeds of plants and animals.

BACK TO THEIR ANCESTORS*

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EDITOR'S NOTE: The interpretation of genetics for the lay reader and the beginning student is still a too much neglected field of endeavor and experiment. The conceptual shorthand of genetics does very well for those who can talk the lingo. It is very thin provender for the uninitiated. This description of a genetic experiment which illustrates "reversion" was originally written for a larger and less genetically sophisticated audience than that of our JOURNAL. To the technical reader it might be dismissed as "kid stuff," entirely too thin to mix with our more technical contributions. As a research report this might be a just criticism. For the purpose it is intended the Editor believes that Dr. Gordon has done a noteworthy bit of pioneering. In this hazardous and perplexing field of popular enlightenment regarding scientific experiments, more experiments in exposition are needed. We hope that from time to time other readers of the JOURNAL will be tempted to present the A-B-C's of genetic research in their chosen fields of endeavor. These will furnish some urgently needed bright new blocks for the genetic kindergartens in the last year of high school and the early years of college.

IF a number of fancy breeds of an animal or of a plant be turned loose to mate at random, such a mixed population will tend to revert, in time, to its common ancestral type. Charles Darwin noticed this phenomenon in the free-living pigeons in the parks of London and described it in *The Variation of Animals and Plants under Domestication.*

Any person strolling in New York City's Battery Park, observing the variously colored pigeons that come fluttering down to pick up crumbs along the paths, may perceive this phenomenon of nature, for these wild flocks are under the control of no man. They appear to be a conglomerate stock, made up of escaped birds from the many lofts that rise above the tenements in lower Manhattan. A few pigeons are off-color, mottled black and white, or red and white; some are predominantly red, others deep blue, but the majority are like their ancestral type, the wild blue rock pigeon, *Columba livia.*

In the days before Gregor Johann Mendel, plant and animal breeders were puzzled by the appearance of "throwbacks" to the ancestral type. Now these are explained in terms of ordinary Mendelian inheritance. The reappearance of ancestral traits is usually brought about by the reunion of hereditary characters which had become separated during the period of their domestication.

Reversions in Plants and Animals

The plant breeder may obtain the original type of the sweet-pea that is still found wild in Sicily by crossing the bush and cupid varieties; and by crossing two different white-flowering sweet-pea stocks, the horticulturist may recreate plants having the wild purple flowers. The corn breeder, by mating two different stocks of dwarfs, can produce a plant normal in height. A rabbit fancier, by crossing the yellow rabbit with the Himalayan breed, may re-establish the wild agouti color.

According to Shisan C. Chen, the wild goldfish (*Carassius auratus*) was first domesticated in China during the Sung Dynasty (A.D. 960-1278). Today, goldfish revert to their ancestral olive-green color so persistently that commercial breeders of the fancier color types find small pickings in any given brood. However, the case for reversion in the goldfish is not complete, for many in a brood that are olive-green when young, if kept alive sufficiently long, eventually display the fancy colors of their breed.

*This is the third in a series of papers on The Genetics of *Xiphophorus hellerii*, the Mexican swordtailed fish.

†Fellow, John Simon Guggenheim Memorial Foundation.

‡This work was aided by facilities provided by the New York Zoological Society.

Reversion at the Aquarium

A clear-cut example of complete color reversion in a tropical fish appeared at the New York Aquarium within the past year when a bright golden swordtail was mated with an almost white, pink-eyed albino. The mating of these two light-colored domesticated swordtail breeds produced the dark, olive-green, wild type, similar to those still found in the jungle streams of southern Mexico.

The wild swordtails were imported into Europe for the first time in 1909, yet during this relatively short period of domestication a remarkably large number of color varieties were developed. The golden and the albino are but two out of a dozen or more strains.

The ancestral olive-green color is really a mosaic pattern of two kinds of tiny pigment-carrying cells, the blacks and the yellows. There are thousands of them in the skin of a swordtail. For example, the area occupied by a single scale may have twenty black cells and almost as many yellow ones.

The Golden Swordtail

The golden swordtail owes its distinctive color pattern to the fact that it has lost all but a few of the black cells, but retains, in full force, all of the yellow ones. It is like the quick-change artist in an old-time vaudeville show, who sheds one coat to reveal a more brilliant one beneath.

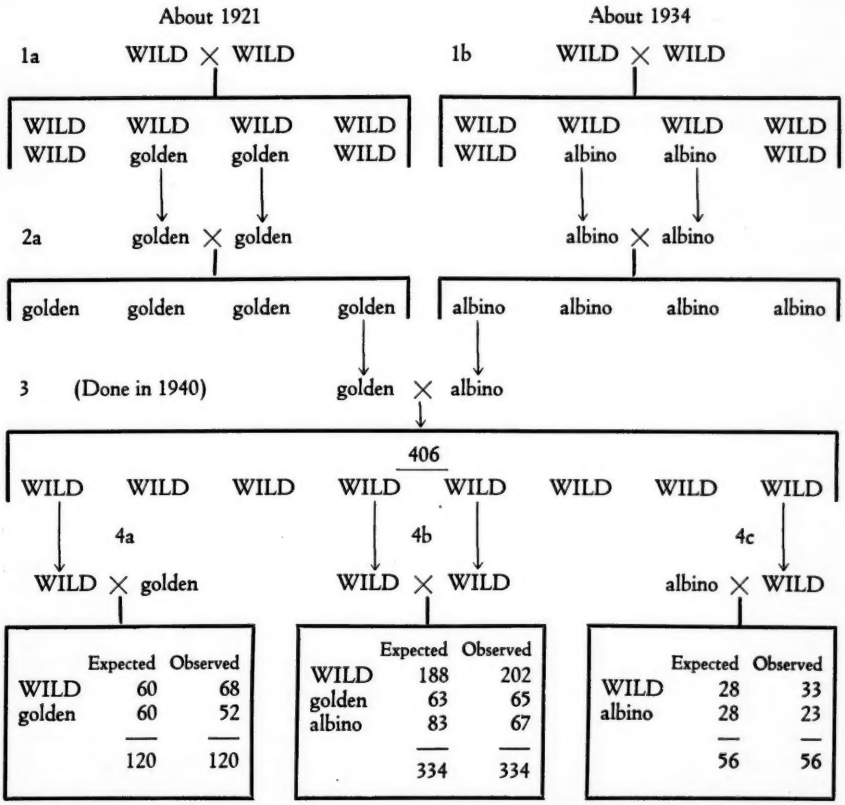
This change from the wild to the golden, from a full complement of many tiny black pigment cells to a rare few, may be expressed this way: the hereditary factor *St* representing the *stippling* effect of the small black cells in the normal wild swordtail mutated from *St* to *st*, from the dominant phase to the recessive, from the olive-green phase to the golden. This must have taken place prior to 1921 for, in that year, Krasper, an aquarist, first described the golden sport. Later, another aquarist, Hildebrand, pointed out that, in one mating, the wild swordtail was dominant over the golden. In 1934, the author showed, in a series of genetic tests, that the golden character in the swordtail was definitely recessive and was typically Mendelian. This has since been confirmed by Kosswig.

The golden sport indicates a breakdown in the swordtail's ability to produce black pigment cells at a normal rate. What this failure is, we do not know for certain. We do know that the machinery for black pigment formation does not break down completely because the golden swordtail has black eyes and a few black cells along its back, but these are so few that they do not diminish its vivid yellow color. It may be that the golden swordtail fails to produce sufficient raw material in the color cells for normal pigmentation to develop. It may also be that the chemical constitution of the cell is different, so that the melanin reactions are not carried to completion.

Pink-Eyed Albinos

The albino with its white body and pink eyes appeared suddenly about 1934. A few of them were discovered in aquaria containing the ordinary, black-eyed, olive-green swordtails. Curiously, these mutants appeared almost simultaneously in American and in European aquaria. Once the albinos were detected and isolated they were easily perpetuated by inbreeding. Like albinism in other animals, this character is usually recessive. Critical studies proving this were made by Kosswig and they have been confirmed by the author's experiments.

The albino mutation brought about the almost complete elimination of the black pigment cells normally present in the skin, in the retina of the eyes, and in many other areas of the body. The albino's eyes appear pink in the swordtail not because of any special red pigment, but because, as in the pink-eyed albino amphibians, birds, and mammals, the clear lens of the eye transmits the color of the blood as seen through the many transparent blood vessels in the retina. The albino mutation involved a second hereditary factor influencing black pigment. In this instance, a dominant factor *I* representing the wild type mutated to the recessive *i* phase. The factor *i* stops practically all the ma-



HISTORY OF SEPARATION AND REUNION OF COLOR GENES IN THE SWORDTAIL

Figure 5

This chart shows the independent origin of the golden and the albino, and the results obtained when these mutations were crossed. The backcrosses of the "synthetic" wilds to golden and albinos show the genetic structure of these differences. Some of the discrepancies in the ratios in the backcross and F_2 results may be accounted for by the differential viability of the three types of swordtails. The albino is the weakest, and the golden is definitely weaker than the wild type. The total of 334 F_2 offspring is made up of the progeny of several females. Some F_1 matings produced F_2 young in the ratio of 9:3:4 so closely as to be remarkable.

chinery responsible for the production of black pigment. With the *i* factor in control, there may be an abundance of raw material for black pigment production provided by the hereditary factor *St*, but none can be converted.

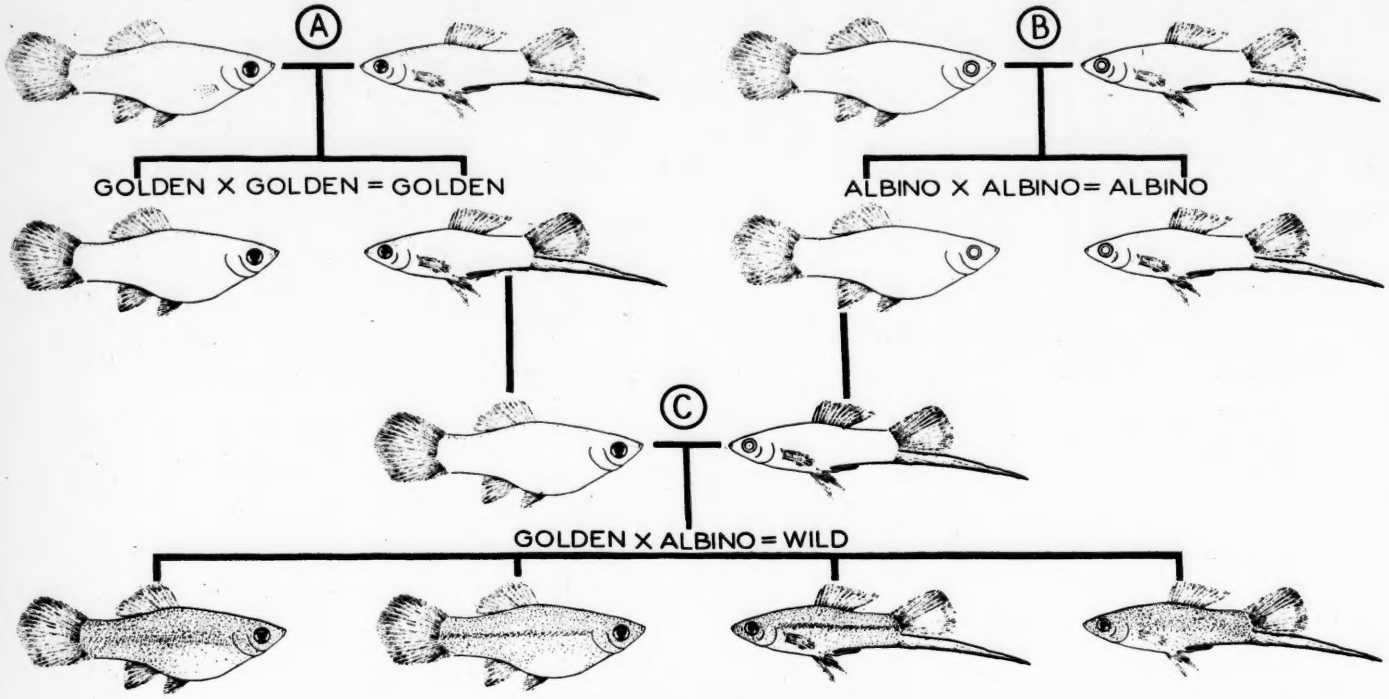
Wild Equals Golden Plus Albino

When a golden swordtail is mated with an albino, the wild, fully pigmented swordtail is recreated because each variety brings to its offspring the essential dominant factor which the other lacks.

From their golden parent, the wild, olive-green swordtail offspring inherit the machinery (*I*), and from the albino swordtail they obtain plenty of raw materials (*St*) for the normal, large-scale production of black pigment cells.

This may be expressed in a diagram:

GOLDEN × ALBINO = WILD, OLIVE-GREEN
ststII × *StSt ii* = *StstIi*



BACK TO THEIR ANCESTRAL COLORS

Figure 6

When the golden swordtails are inbred, they produce nothing but golden; when the albino swordtails are inbred, they produce nothing but albinos. When the golden swordtail is mated with the albino, they produce young all of which have the coloring of the wild swordtail.

The Wild in Hiding

Aquarists and geneticists have frequently noticed a large number of reversions to the wild type among the young of the highly colorful montezuma variety of the swordtail. In this variety the number of throwbacks is consistently about one-third of the entire brood. These continuously reappearing wilds are annoying and puzzling to the aquarists who want to develop a true-breeding type of montezuma. This curious breeding behavior may be explained as follows:

The albino or golden swordtails are recessive and owe their distinctive coloration to a loss of the black pigment characteristic of the wild type. The montezuma, on the other hand, is a dominant trait and adds a pattern that covers the wild. If you can picture the wild swordtail outfitted in a conservative suit of grey, then perhaps you can visualize the montezuma clothed in a dazzling topcoat that is bright orange-red and as black-spotted as a leopard's skin. If the montezuma were to lay aside its gay topcoat, and it does this frequently, the gray suit of the wild swordtail would reappear.

The golden swordtails breed true, so do the albinos, but the montezuma, at least those we have had, never do. Montezuma swordtails are like yellow mice for yellow mice never breed true either.

Breeders of fancy mice now know, thanks to the pioneer French geneticist, Cuenot, that when two dominant yellow mice are mated, they can expect only two-thirds of the progeny to be yellows. The pure-breeding yellow mice never emerge from their mother for they die in the embryonic stage of development.

The breeding behavior of a pair of montezumas may be diagrammed as follows:

P-1	MONTEZUMA × MONTEZUMA	
	Momo	*Momo*
F-1	Expected	Observed
MONTEZUMA		
MoMo	25%	none
Momo	50%	66-2/3%
WILD, reversion		
momo	25%	33-1/3%

There seems to be something deadly about some true-breeding dominant types which kills them before, or shortly after, they are born. Just what goes wrong to kill off the true-breeding montezumas is not known as yet.

The montezuma swordtails, because of their inability to breed true, are a peculiar lot and, in mating them to other varieties, they produce reversions to the wild type in differing proportions. For instance, when two montezumas are mated together, they throw one wild to two montezumas. When a montezuma is mated to a golden swordtail, the young are either montezuma or wild, in the ratio of one to one. And if a montezuma offspring of a montezuma-golden cross is mated back to a golden swordtail, about one-quarter of the young revert to the wild.

Thus, among matings of certain domesticated swordtails that differ in appearance from the wild, reversion to the ancestral type may take place in all of the brood, in half, a third or a quarter.

Black Fins Disappear

In talking over this problem of swordtail reversion with an aquarist, Fred Flathman, of Woodhaven, Long Island, N. Y., I learned that the same sort of phenomenon occurs when a black-finned yellow swordtail and an albino are crossed. Flathman made this mating because he thought he might be able to develop a new, commercially-successful color variety. Instead, Flathman obtained only throwbacks to the wild type —the black tail had disappeared together with the yellow and the albino characters. These unexpected results were so disappointing to the aquarist that he sold the entire lot as common wild swordtails for whatever they would bring. We aim now to repeat these experiments.

Wild, Golden and Albino

The wild-colored offspring of the golden and albino parents, after being mated brother to sister, are producing, out of every sixteen born, nine young that are typically wild, three that are golden and four that are albinos. One out of every

four albinos must be a double recessive, but as yet they cannot be distinguished from the ordinary albinos. They may eventually turn out to be a more attractive variety; perhaps a super-blond swordtail will emerge.

Uses for the New Albinos

Whether or not the new albinos will be attractive is not particularly important. But they will be extremely useful in current genetic studies of melanomas that develop in fish hybrids when the albino swordtail and the spotted or black-banded platyfish are mated. Breider and Kosswig have shown that when a black-banded hybrid is back-crossed to an albino swordtail and their black offspring are back-crossed again to the albino, some of the young of the last mating develop tumors without black pigment. With the cooperation of Mr. Flathman we have succeeded in obtaining fish hybrids with black tumors in the first generation and colorless tumors in the offspring of the second generation. Melanomas that are white instead of black are biological anomalies.

The ordinary albino swordtails transmit micromelanophores (the technical name of the small black pigment cells) to their hybrids, just as they transmit these same cells to their own wild, olive-green-colored young of their own species. With the development of the new strain of double recessive albinos, it will be possible to eliminate the micromelanophores which are regarded as non-essential for tumor production; thus, pathologically, the study of the colorless melanomas can be simplified. More emphasis will be placed upon the large black pigment cells, the macromelanophores, brought to the hybrid by the spotted platyfish. Under the influence of the albino factor, *i*, it appears that macromelanophores, just as the micromelanophores, cannot elaborate melanin pigment, yet the large colorless pigment cells may still be able to evoke colorless melanomas in the fish hybrids.

Practically nothing is known about the inheritance of melanomas in man, the mouse or the horse; still less is known about human colorless melanomas. Melanoma studies with fishes should be of value in interpreting the development of these neoplastic diseases in the more specialized vertebrates, including man. Specific proof of the closeness of fish to man with reference to the similarity of cell types in each has recently been indicated by Grand, Gordon and Cameron, in a cooperative study between the New York Aquarium and New York University.

In the tissue culture laboratory of the Department of Biology of the Washington Square College, the biologists were successful in growing, for the first time, tiny fragments of fish melanomas in a medium composed of fish serum and chick embryo extract. They compared the cell types that emerged from the fish melanoma fragment with the cells that emerged from fragments of mouse and human melanoma previously studied. They found that the cell types, the melanoblasts, the melanin-bearing macrophages, and the fibrocytes, in fish, in mice and in men were identical in structure.

Conclusions

The mating of the golden swordtail with the albino was conducted as a routine study of inheritance in fishes, a subject of which comparatively little is known. Reversion to the ancestral color pattern was demonstrated. The double recessive albinos obtained as a by-product of this study will be of great value in explaining the curious pathological anomaly, colorless melanomas.

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COLD SPRING HARBOR SYMPOSIUM ON GENES AND CHROMOSOMES

FOR the past nine summers the Biological Laboratory at Cold Spring Harbor has invited a group of mathematicians, physicists, chemists, and biologists to take part in a symposium upon some selected aspect of quantitative biology. Previous symposia lasted for five weeks and the majority of participants remained in residence at the Laboratory for a part of that time. This year the program containing approximately the same number of papers was condensed into two weeks. Such modification helped a great deal in keeping the group together and the majority of participants remained in residence during the whole session of the symposium.

The meetings are conducted with a minimum of formality, and no limit is placed either on the length of papers or on the discussion following them; indeed, much of the discussion inevitably takes place between individuals after the meetings at which papers are read. The discussions are then revised by those taking part in them, and, together with the papers, are published in a volume of the *Cold Spring Harbor Symposia on Quantitative Biology* series. These volumes give a true picture of the opinion of the group at the time.

The subjects for the symposia are selected on the basis of their being subjects in which rapid advance has recently taken place along quantitative lines. Thus in 1933 surface phenomena were discussed; in 1934 various aspects of growth; in 1935, photochemical reactions; in 1936, excitation phenomena; in 1937, internal secretions; in 1938, protein chemistry; in 1939, biological oxidation; and in 1940, permeability. This year the theme was genes and chromosomes. It ought to be pointed out that in preparing the program and in selecting the material for publication, comparatively little attention is given to the subject being as comprehensively covered as it would be in a monograph or textbook. Some of the papers may be of the nature of reviews, but the majority are concerned with a presentation of specialized and even controversial aspects of the subject.

When it was decided that this year's symposium would deal with a problem integrating genetics and the borderline fields of physics, chemistry and mathematics, it seemed logical to select "Genes and Chromosomes — Structure and Organization" as the topic of the symposium. Mathematics are regularly used in the analysis of genetic problems so that whichever topic were selected it would have included mathematics. For a number of years, in the studies dealing with the structure of genes and chromosomes physical and chemical methods have been extensively employed and physical and chemical interpretations have been utilized. At present the work on these problems is at a stage where an organized discussion with participants representing borderline fields seemed profitable.

Since 1936 a small group of biologists, biophysicists and biochemists interested in the gene problem has been holding conferences at regular intervals. This group was the nucleus of the 1941 symposium, itself an expanded gene conference.

In discussions between geneticists and physicists among the questions invariably asked are: What is the approximate thickness of the chromosome threads; when do they divide; how close together do they lie; how tightly are they coiled; and what is their number? The experimental evidence pertaining to these and related questions was presented by C. A. Berger, L. C. Huskins, B. R. Nebel, and H. E. Warmke in the first section of the Symposium dealing with the "Structure of chromosomes as revealed by optical methods."

It is generally assumed that in giant salivary gland chromosomes found in the larvae of flies the primary chromosome thread is multiplied a great many times. The structures which are visible in salivary gland chromosomes are also pres-

ent in the chromosomes of other cells but they cannot be detected since they are too fine for our microscopes. Thus salivary chromosomes constitute material unusually suitable for studies of fine structures and for the study of changes induced in chromosomes. Known facts dealing with the problem in which salivary chromosomes were utilized were discussed by P. A. Cole, E. Sutton, D. Mazia, C. W. Metz, T. S. Painter, and J. Schultz in the second section.

The third section dealt with the "Spontaneous and induced changes in chromosome structure" and consisted of papers by J. G. Carlson, M. Delbruck, U. Fano, B. P. Kaufman, B. McClintock and K. Sax. It is known that chromosomes break spontaneously and also that such breaks may readily be induced by X-rays and similar radiations. Since the occurrence of a break is undoubtedly connected with some chemical reaction, the studies of the breaks may give a clue for an analysis of the chemical properties of chromosomes.

Spontaneous and induced changes in genes were discussed in the fourth section of the Symposium by M. Demerec, J. W. Gowen, A. Hollaender, H. J. Muller, H. H. Plough, M. M. Rhoades, and L. J. Stadler which was designated as "Mutations." An emphasis was placed on the problem of spontaneous mutations which has lately been too much neglected. It is felt that data on spontaneous mutations may help to clarify certain problems dealing with the induced changes and thus contribute toward better understanding of chemical processes involved in mutational changes. However, a full opportunity was afforded for discussion of changes in genes induced by various physical agents, since at present these data constitute the best material for interpreting the physico-chemical properties of genes and chromosomes.

"Physical aspects and tools" were discussed in the fifth section of the symposium by I. Fankuchen and V. K. Zworykin. New tools like the electron microscope may well prove an important factor in the study of properties of very fine structures such as chromosomes. Thus the information about the electron microscope may accelerate the work in that field. For interpretation of changes induced in genes and chromosomes by radiation a familiarity with certain physical aspects is essential.

It seems very probable that genes are large organic molecules in which protein and nucleic acid are present. Thus a discussion of the properties of giant molecules and particularly of proteins, nucleic acid and viruses were topics which logically belonged in this Symposium. They were taken up by A. Claude; J. S. Fruton; J. P. Greenstein; H. Mark; A. E. Mirsky; D. Rittenberg, A. Rothen, B. F. Chow, R. O. Greep, and H. B. Van Dyke; and W. M. Stanley. Attention of the group was called to the evidence which indicates that frequent atomic interchanges occur in living organic molecules since this may have an important bearing on the visualization of the activity of a gene. A general resumé was presented as a concluding lecture by H. J. Muller.

It has generally been assumed that in order that a symposium be a success the attendance should be limited to a relatively small group, since it is believed that a large group hampers the free discussion which is an essential part of a symposium. It has been the policy of the Biological Laboratory to have the symposia open to all who desire to attend, and this policy was followed this year. It was rather disturbing when instead of the expected attendance of 35 to 50 persons, we had an attendance of about 120. However, as soon as this first session was over, it was evident that large attendance not only did not prevent free discussion, but that it actually stimulated it. Our symposium this summer has demonstrated that the interest and not the size of the group determines the success of a conference.

The proceedings of the symposium have just been published in a volume of about 300 pages (8"x11") containing 34 papers, edited discussions in which 85 persons participated, many line-drawings, 14 half-tone plates and an index.

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CROSSES BETWEEN INBRED STRAINS OF MICE

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THIS report covers the first phase of an experiment by the United States Department of Agriculture to determine how inbred strains of animals may be used in the development of improved types. Much has been accomplished with plants, corn in particular, by this method.[2,3] The principles involved may also be applicable and practical in animal breeding. The Department of Agriculture has conducted much research on the effects of continued close inbreeding on guinea pigs, but not enough strains were available to make an extensive study of the crosses. Several highly inbred strains of mice were already available from various laboratories. Their prolificacy and the short time required to develop several generations made them preferable to guinea pigs for an experimental survey of the possibilities.

The plan of the experiment is to make crosses reciprocally between the inbred strains to determine the effect on various measures of fertility, viability, and growth in the first generation. Those which cross favorably are to be mated back to one of the parent strains or to a third inbred strain to determine if further improvement takes place. From the progeny showing further improvement new strains will be developed, selection being made for desirable qualities. This report deals with the differences between the inbred strains themselves, and the results of the first cross between strains. Limited data are available on a few crosses of F_1 females to a male of a third inbred strain.

Measures of fertility include the percentage of matings which were successful in producing litters, the regularity of breeding as measured by percentage of litters born within 24 days after mating, and the number of young born per litter.

There are several measures of viability which might be used, but the one selected here and which is considered most applicable to animal breeding is the actual number surviving to 120 days. This is dependent on prenatal and postnatal mortality and corresponds to an age beyond which swine would be marketed.

Growth is measured by weights at weaning (30 days) and at 120 days.

Comparison is made between the inbred strains, between the inbreds and the F_1 young from the crosses, and between the young from F_1 females when crossed to a third inbred strain. Three random-bred strains are also used for comparison. Table I shows the strains used, their place of origin, their original designation, the designation used by the U.S.D.A., and the approximate number of generations of inbreeding when purchased in the spring of 1938.

Comparison of the Inbred and Random-bred Strains

The strains differ considerably in percentage of successful matings, ranging from 66 per cent in strain *E* to 87 per cent in strain *S*. Three of the inbred strains, *S*, *C*, and *B*, are equal to or better than *L*, the best of the random-bred strains in percentage of successful matings. In general, however, the random-bred strains have a higher percentage of successful matings than the inbreds.

Percentage born within 24 days after the mating was made was highest in strain *W*, which also exceeded *K*, the best of the random-bred strains in this respect. Again the general average for the random-bred strains was above that of the inbreds.

Litter size was lower in the inbred strains than in the random-bred except for *Cd*, which ranked with *K*, the lowest of the random-breds.

In these measures of fertility the same

strain does not rank equally for the three measures used. For example, *S*, ranking first in percentage of successful matings, is sixth in percentage born within 24 days after mating, and ranks equally with *Br* for second place in number per litter.

Number raised to 120 days is closely dependent on litter size as may be seen by the close parallelism in ranking of these two characters. Two of the random-bred strains are better than any of the inbreds in number raised.

Weights at weaning and at 120 days are shown for males only, since the weight of females is affected by recurring pregnancies. Birth weights were disregarded because the litter is weighed as a whole and individuals cannot be identified at this age. Only two of the inbred strains stood out as being superior to the others in weight, namely *S* and *E*. Of the random-bred strains *L* was the largest at both ages.

These results show that the inbred strains differ among themselves in the characters studied and that superiority in one character does not necessarily mean superiority in all. In general the random-bred strains excelled the inbreds in the characters studied, but one random-bred strain, *M*, was inferior to several of the inbreds.

F_1 Litters

Although the sires and dams of the F_1 litters are themselves inbred, more than half the F_1 litters showed improvement over both inbred parent strains in the three measures of fertility given. In several of the hybrids the values are higher than for the random-bred strains.

Number of young raised to 120 days was greater for most of the F_1 young than for the inbred or random-bred parent strains.

Weights at weaning and at 120 days in the hybrids showed an increase over the inbred parent strains. In crosses between an inbred strain and random-bred strain *L*, the weights were not so great as for strain *L*.

These facts seem to indicate that the union of two inbred strains increases vigor in general as shown by a higher percentage of successful matings; more young born, which in itself may indicate a higher percentage of fertilized ova or a higher viability of the fetuses after fertilization; higher viability between birth and 120 days; and increased vigor of the young themselves as shown by their weights at weaning and at 120 days.

Litters from F_1 Dams

Hybrid dams mated to a male of a third inbred strain gave even better results than the matings between two inbred strains. In nearly every cross studied there was an increase over the F_1 litters in the characters studied. Percentage of successful matings, litter size, and number of young raised to 120 days especially showed marked increases.

In two cases, namely *E-Br* and *H-E* dams, the number of young raised to 120 days was more than 100 per cent greater than from the inbred strains from which the dams descended. In many other cases the increase was 80 to 90 per cent.

While weights at weaning and at 120 days showed an increase over weights of the F_1 young, the percentage increase was not so great as for number raised, amounting to 7 to 12 per cent. Apparently the great increases in the measures of the characters studied over those in the first cross are due to the general increased vigor of the hybrid dams.

Undoubtedly the results are affected somewhat by small numbers, yet they are consistent and probably indicate the general trend to be expected when larger numbers are available.

A Synthesized Strain

One line has been synthesized from a cross of a silver (*Si*) male to females of strains *A* and *C*. The *Si* females failed to produce progeny to breeding age; therefore, data are not available as to the performance of this strain. One F_1 litter was produced from the *A* female and three from the *C* female. Seven young, all raised to 120 days, were produced by the *A* female, while the *C* female's litters averaged 11 young born, with 10.7 surviving to 120 days. The average weight

of the young in these litters at 120 days was 30.1 gm., there being only 0.7 gm. difference between the litters from the *A* and *C* females.

An F_2 generation consisting of 8 litters from *SiA* and 12 from *SiC* was produced. The F_2 young of these crosses were then combined in matings and selection was made for the silver character for four or five generations, no further attention being given as to *A* or *C* origin. Several full brother-sister matings were made. The average litter size for all matings after combining the F_2 generations was 9, with 7.4 raised to 120 days. Ninety-three per cent of these matings proved successful. This is better than these three characters, litter size, number raised to 120 days, and percentage of successful matings, for any of the inbred or random-bred strains. Average weights of 15.2 gm. at weaning and 30.4 at 120 days are better than corresponding weights for strains *A* and *C*, but are not superior to some of the other inbred strains.

Summary

The results of the mouse crosses agreed very closely with those between inbred families of guinea pigs, as reported by Eaton.[1] Crosses between some strains showed increases over the inbred parent lines in various measures of fertility, viability, and growth. Other strains appeared to be incompatible in crosses and gave results inferior to either parent strain. In the guinea pig crosses the dam had a strong influence on the growth of the young. This was not noted in the mouse crosses.

Combination of three inbred strains gave a greater increase in the measure of the characters studied than the combination of two strains. The greatest increase was in measures of fertility and viability. These results were doubtless due to greater general vigor of the hybrid F_1 dams.

Results in a strain synthesized by crossing the F_2 animals from two different F_1's having a common male parent, point favorably to the possibility of developing a strain with a higher percentage of successful matings and an increase in number of young born and raised to 120 days, but did not necessarily prove superiority in growth characteristics as shown by weights at weaning and 120 days.

This or a similar procedure will be followed in developing other strains from the crosses already made which show improvement over the parent strains.

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TABLE I. Strains of mice used in cross-breeding experiment.

Source of mice	Original designation	U. S. D. A. designation	Approximate generations inbreeding
Jackson Memorial Laboratory	C	C	40
"	c6	C6	15 +
"	C-3-H	A	45 +
"	C-57 black	B	40 +
"	C-57 brown	Br	40 +
"	A	H	60 +
"	AW	W	13 +
Ohio State University	Silver	Si	--
"	Erwin	E	20 ?
"	Swiss	S	20 ?
Food and Drug Adm., U.S.D.A.		K	Random bred
Zool. Div., U.S.D.A.		L	"
" "		M	"

The inbred strains are maintained by brother-to-sister matings while in the random-bred strains no matings are made more closely related than third cousins.

TABLE II. Measures of fertility, viability, and growth in inbred and crossbred strains of mice.

	Strain	Percentage of successful matings	Percentage born 19-24 days after mating	Average number per litter (Total born)	Number raised to 120 days	Average weaning weight (grams)	Average 120-day weight (grams)	Number of litters
Inbred	A	79.0	74.3	5.2	3.7	14.6	28.7	26
	B	83.6	70.5	6.3	4.0	15.5	29.0	33
	Br	68.7	63.1	6.3	3.4	13.5	27.2	20
	C	83.1	56.5	6.4	3.4	14.5	27.7	43
	C6	74.5	57.9	7.2	3.4	13.3	26.6	20
	E	66.4	70.7	5.9	4.4	16.2	30.8	25
	H	73.2	70.8	4.9	3.8	14.5	28.7	44
	S	87.2	68.8	5.4	3.7	16.9	31.2	118
	W	72.8	79.7	6.4	4.6	14.2	26.6	22
Random bred	K	80.7	76.1	7.1	5.2	14.7	29.7	49
	L	92.7	74.3	8.2	7.2	17.4	33.0	36
	M	77.6	74.2	7.4	5.4	16.2	29.8	26
F_1 litters (sires and dams inbred)	AB	78.0	66.7	7.0*	6.2*	16.5*	31.8*	6
	AE	62.5	83.0*	8.4*	8.0*	17.0*	31.8*	5
	EA	63.0	86.7*	6.0*	4.8*	18.4	32.2*	7
	CCH	88.9*	78.0*	7.0	5.4	14.4*	29.9*	9
	CH	50.0	83.3*	6.0	5.0	11.6	22.9	12
	CS	75.0	66.7*	8.5*	8.5*	14.7	29.4	8
	SC	80.0	87.5*	7.2*	6.9*	15.8*	31.6*	8
	WBr	70.0*	100.0*	7.4*	5.2	16.5*	31.4*	10
	WCH	100.0*	80.0	6.8	6.2*	14.9*	31.1*	10
	WS	88.7*	83.3*	7.5*	7.0*	15.8	30.1	8
	SB	87.5*	82.8	6.9*	6.9*	17.0*	32.3	8
	SCH	90.9*	70.0*	7.2	6.8*	14.9	31.9*	10
	SW	71.4	80.0	8.0	6.4	17.6*	32.6*	7
	WBr	100.0*	60.0	10.0*	9.0*	15.2*	29.5*	5
F_1 litters (sires and dams random bred)	LB	86.7	83.3*	9.0*	8.0*	17.2	31.5	9
	LC	100.0*	86.7	9.1*	8.2*	16.2	30.2	11
	MB	100.0*	75.0*	7.3*	7.3*	15.5	31.3*	10
Litters from F_1 dams	AB	100.0**	87.5**	8.8**	8.7**	17.3**	31.9**	9
	AE	100.0**	100.0**	7.8**	6.9**	17.7	32.1**	8
	EA	100.0**	75.0	9.0**	8.0**	16.9**	32.0**	8
	CCH	90.0	100.0**	9.4**	9.0**	16.0**	31.7**	9
	CH	100.0**	92.8**	7.8**	6.8**	16.9**	31.1**	14
	CS	80.9**	80.0	11.4**	10.0**	15.1**	29.7	10
	SC	100.0**	84.0	10.1**	9.9**	18.3	31.9**	8
	WBr	88.7**	93.3	12.0**	11.5**	16.1	32.9**	7
	WCH	84.2	76.0**	8.8**	8.7**	17.1**	32.1**	20
	WE	100.0**	92.6	10.7**	10.6**	14.9	30.6**	8
	WS	92.8**	84.8**	9.2**	9.0**	15.6	30.9**	16
	SCH	90.0	72.2**	9.0**	8.4**	18.6**	33.7**	12
	SW	88.7**	83.3**	9.5**	9.0**	15.5	30.9	7
	WBr	100.0**	75.0**	10.2**	9.8**	16.9**	31.1**	8
	LB	100.0**	100.0**	9.8**	9.5**	18.3	32.1**	9
	LC	100.0**	87.1	10.0**	9.6**	17.0**	30.7	7
	MB	100.0**	77.8**	9.4**	7.9**	17.4**	33.8**	9

* Equal to or better than both parent strains.
** Equal to or better than F_1.

RACE—PRE- AND POST-GENETIC

PUBLISHED under the imprint of the Catholic University of America with a heartening preface by the Rector, Bishop Joseph W. Corrigan, this volume* represents a welcome addition to the already large literature on the "race problem." The volume is, however, of very unequal merit.

Professor H. S. Jennings' chapter (pp. 3-73) on "The laws of heredity and our present knowledge of human genetics on the material side," introduces the reader to the elementary principles of heredity, and then proceeds to a discussion of the mechanism of heredity in man. Limitations of space prevent this second part of Jennings' contribution from being either as full or as good as the first part. There is, indeed, very little which specifically refers to the relation of genetics to the problem of race in man. In his last three pages Jennings discusses "racial characteristics," but the reader is given no really helpful account as to the manner in which human ethnic groups may be conceived, in the light of genetic knowledge, to have originated. But read as an introductory propadeutic to the study of the problem of the genetics of human raciation this contribution could hardly be bettered.

Professor Charles A. Berger next discusses the problem of "Human psychological inheritance" (pp. 77-92). This is a rather general article in which the reader is perhaps very properly left with the impression that too little is at present know nabout the subject for any very definite generalizations.

Professor Thomas Verner Moore contributes a discussion of "Human and animal intelligence" (pp. 95-158), but good as it is, it can by no stretch of the imagination be conceived to belong in the present volume. This is a valuable review of studies relating to the non-human primates in particular as compared with man taken in general, with no reference whatever to the "race problem."

Dr. Ales Hrdlicka's account of "The Races of Man" (pp. 161-187) is written in a completely pre-Mendelian style, precisely as if modern genetics had never existed. Nonetheless Dr. Hrdlicka manages to say things that are very well worth saying and repeating. His classification of human stocks may be regarded as a not-too-serious post-prandial exercise of a kind which the geneticist will know how to appreciate but which, unfortunately, the general reader will not.

Professor Robert H. Lowie's discussion of the "Intellectual and cultural achievements of human races" (pp. 191-249), constitutes an admirable analysis of cultural relativity. With both skill and learning Professor Lowie convincingly shows that in nature of intelligence, incidence of genius and comparative morality the different peoples of this earth exhibit nothing which upon careful study would lend to the conclusion that, in any of these respects, could the observed differences be interpreted in "racial" terms.

Professor Otto Klineberg in his examination of the problems and data of "Mental testing of racial and national groups" (pp. 253-294) has written what is undoubtedly the best short discussion of that subject that we have. It cannot be too highly recommended. As our leading and most acute student of the mental testing of different ethnic groups Professor Klineberg's conclusions are worth repeating here. He writes:

> We have the right to say that the results obtained by the use of intelligence tests have not proved the existence of racial and national differences in innate mental capacity; and also that as the social and economic environments of the two ethnic groups become more alike, so do their test scores tend to approximate each other. We have no right to conclude that there are no racial differences in mental ability, since it is conceivable that new techniques may some day be developed which will indicate that such differences do exist. This is unlikely, however, and we may state with some degree of assurance that in all probability the range of inherited capacities in two different ethnic groups is just about identical. (p. 284.)

Each chapter is accompanied by a bibliography, and there is an index.

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*Scientific Aspects of the Race Problem. The Catholic University of America Press, Washington, D .C. (New York: Longmans, Green & Co.), 1941., ($3.00), pp. ix-302.

AN HEREDITARY ABSENCE OF THE INCISOR TEETH

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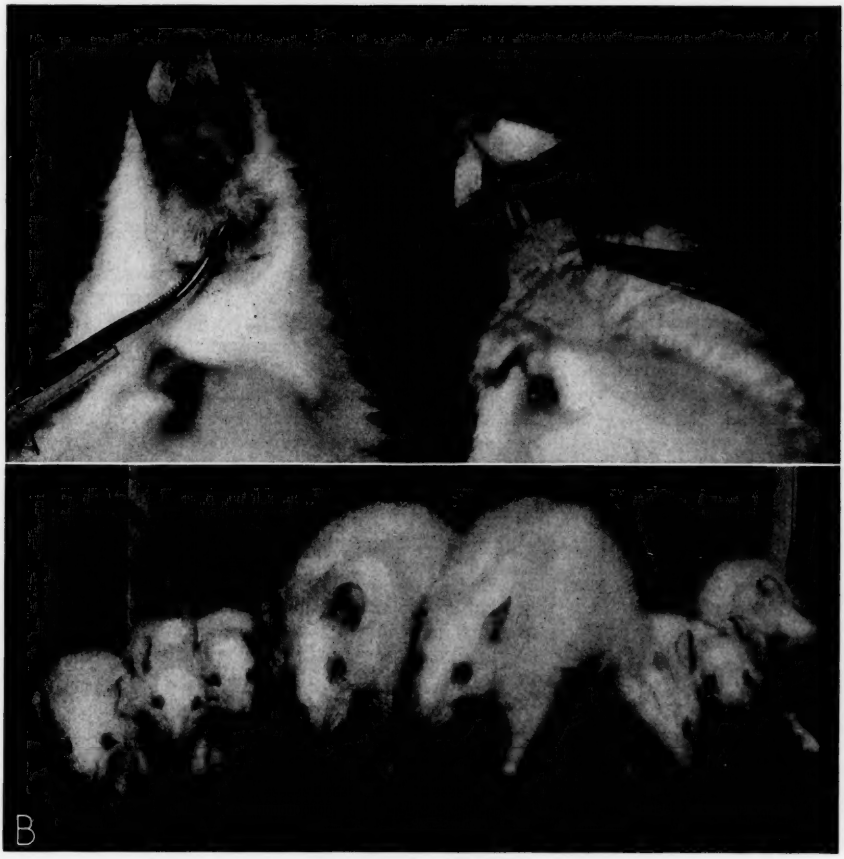
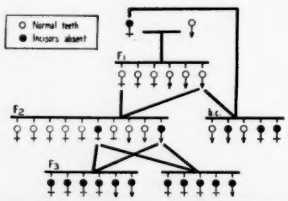


INCISORS ABSENT
Figure 7

A—Rat at left is the original defective female showing absence of upper and lower incisors. Rat at right is her son with normal incisors. *B*—A litter of six incisorless offspring with their incisorless parents all showing a mild eye defect. The young were 26 days old.

IN an operative procedure employed on young rats in this laboratory the animal's head is restrained by means of a small rubber band fastened about the upper incisor teeth. Two years ago a 21-day-old female rat was found which had not developed these teeth (Figure 7*A*); the corresponding incisors on the lower jaw were likewise absent. There was a long, fleshy and highly vascular papilla protruding from the mandibular symphysis. An examination of the literature has revealed no reports of a similar condition.



RECESSIVE INHERITANCE

Figure 8

Showing the hereditary behavior of the incisor anomaly in the F_1, F_2, F_3 generations and the backcross (b.c.).

This defective animal was put aside for further observation. By the time she had reached maturity the incisors had not yet erupted. She was mated with a normal male (not a litter mate) from the colony and none of the offspring showed an abnormality of the teeth. Further matings were made as shown in Figure 8. In the F_2 generation, two of a litter of 10 animals showed the incisor anomaly. In the backcross mating of a male from the F_1 generation to his mother the anomaly was present in three of five offspring. The ratios of defective animals obtained indicated that this tooth anomaly was inherited as a simple Mendelian recessive factor. By mating two of the defective animals in the F_2 generation two litters, of five and six animals each, were obtained in which the defect appeared in all the offspring. Therefore, all the evidence so far obtained indicates that the incisor anomaly is inherited as a simple Mendelian recessive factor.

It should be mentioned that the animals in this colony are fed a complete diet of mixed ground food, a factor which undoubtedly favored the survival of these defective animals. These animals grow more slowly than their normal littermates after weaning. The majority of the incisorless animals do, however, eventually attain the size of normal adult animals in the colony. Sexual maturity especially in some of the females may be considerably delayed. The animals with the tooth anomaly also show without exception, unlike other animals in the colony, a hemorrhagic exudate from the eyelids which produces an appearance (Figure *7B*) somewhat similar to the xeropthalmia seen in animals suffering from a deficiency of Vitamin A. In these incisorless animals, however, the cornea remains clear and unaffected in contrast to the damaged cornea characteristic of Vitamin A deficiency. The fact that the incisorless animals are fertile and bear young indicates further that the eye condition may not be due to dietary factors.

The original incisorless female rat was killed at 22 months of age and at this time the incisor teeth remained entirely absent.

The molar teeth appear by gross examination to be distinctly abnormal. Roentgenographic and histological studies of the jaws of these animals are being made by Dr. Isaac Schour.

✦

HEREDITY AND DAIRY PRODUCTION

A SPECIAL number of the *Journal of the Swedish Academy of Agriculture* presents (in English) one of the most thorough and up-to-date studies* yet made concerning the factors or influences which cause cows' records to be high or low. Although many pages and analyses are concerned with evaluating and correcting for non-genetic influences, the role of heredity is ever present in the authors' minds and the concluding pages are devoted to that.

The records were collected over a 15-year period in 13 herds of Swedish "Red and White" cattle. The feeding practices were good and most of the cows were milked three times a day as long as their daily yield was more than 10 to 15

*Causes of Variation in Milk and Butterfat Yield of Dairy Cows. Ivar Johansson and Arthur Hansson. *Jour. of the Royal Swedish Academy of Agriculture.* Jahrg. 79. Nr. 6½. 127 pp. 1940.

kilograms of milk. The milk was weighed and tested at intervals of two or three weeks. The 15 year period began in 1924 when presumably the effects of the feed shortages during the first World War would already have disappeared. Perhaps the chief contrast with American conditions, so far as can be judged from the report, was that the average age of heifers at their first freshening was as late as 34 months and that production during the second lactation was only a little above that in the first lactation, although later lactations followed nearly the curves found in American data. About 3,000 cows and nearly 7,000 records were involved.

After comparing several different measures of yield the authors chose to use the yield during the first 300 days of the lactation. The interrelations of the non-genetic influences had ot be considered when devising suitable corrections for those influences. Corrections were concluded to be worth making for four factors: Lactation number, variations in age at calving for the first and second lactations, lengths of preceding and of summer and winter calving. The correction for age (as expressed by lactation number) was the most important of these. Expressing records as deviations from the herd averages (Stalldurchschnitt method) of course reduced the over-all variance distinctly but the authors are uncertain that this correction should be made. They think that the differences between herd averages were in considerable part genetic and not wholly environmental. Because the same cow tended to have similar lengths of dry periods lactation after lactation, variations in that were considered largely genetic. Corrections for length of calving interval were thought adequate to take care of non-genetic differences in dry period also.

For some factors the optimum was intermediate and moved with other factors. For example the optimum calving interval which includes the first lactation was about 420 days, that including the second lactation was about 400 days, and for later lactations it was about a year. Cows calving in the summer produced about ten per cent less than cows calving in the autumn and fall but this varied much from herd to herd, apparently as the result of differences in feeding and management policies. The regression of butterfat production on preceding dry period was curvilinear, the optimum dry period being about five to seven weeks. The average intra-herd correlation between fat percentage and milk yield in the same lactation was —.17 when all lactations were pooled, but this was a compound effect being made up of a correlation of approximately zero within groups of lactations by the same cow and about —.25 as between the averages of cows kept in the same herd.

Three indexes were tried for measuring persistency: the length of the current dry period, the ratio of the production during the second 100 days to that during the first 100 days, and the ratio of production during the third 100 days to that during the first 100 days. The first and third of these gave best results in the first lactation and were about equal to each other in usefulness. For later lactations the ratio of the production in the second 100 days to that in the first 100 days was as good a measure of persistency. Moreover it required no correction for the length of current calving interval.

Among the first three lactations the first was the most reliable as an indication of the cow's real ability while the second was the poorest, but in these data the heifers first freshened at a late age and production in the second lactation was relatively low as compared with American data.

The hereditary portion of the variance in individual records was estimated to be about as follows:

Fat percentage:	70 to 80 percent
Total milk yield or fat yield:	30 to 40 percent
Persistency:	15 to 30 percent
Calving intervals:	0 to 5 percent

The authors have given more attention to how selection may have altered the data than in any other extensive study of dairy data yet published. Yet in considering this they have assumed

that the early records made by cows which were saved because those very records were high will be fairly representative of those cows. In fact those records will generally be a little higher than fairly indicates the real abilities of the cows which made them. Correction for incomplete repeatability of single records (Repeatability was .36 on an intra-herd basis in these data for corrected records of cows which each had five or more records: presumably it would be a little larger on a less highly selected group.) would have removed this bias. This is a small point and would not have altered their conclusions, except perhaps a little regarding age correction, etc. Perhaps the authors dismissed too summarily the possibilities in using yearly records. They favor an additive correction for age but do not appear to have considered whether this would give records corrected to maturity the same standard deviations as actual mature records.

These minor points are the only flaws which the reviewer noted to mar the principles or procedure. Everyone who has much occasion to study dairy data will profit by having a copy of this on his desk or at least opportunity to study it in detail.

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Iowa State College.

✦

"DOMESTICATION GENES"

An article published in the newspapers on October 26th may herald a far-reaching discovery in the genetics of intellect and emotion.

This dispatch reports the findings presented by Dr. Clyde E. Keeler of the Wistar Institute before a Zoological Seminar at the University of Pennsylvania on October 23rd. In discussing the multiple effects of coat color genes in the rat Dr. Keeler reported some remarkable conclusions at which he arrived by reworking data on rat anatomy compiled by the late Dr. Henry H. Donaldson over a period of many years in addition to Dr. Keeler's own observations. Dr. Donaldson, among his multitude of biological interests, was fascinated by the problem of domestication. He compiled dissection data upon a great number of rats that had been bred and reared for growth studies by Dr. Helen Dean King of the Wistar Institute, and he attempted to follow their anatomical modifications in the direction of the Wistar Albino rat which form he thought they would eventually assume due to the environmental pressure of captivity. From these records Dr. Donaldson was unable to solve the problem of domestication.

According to this account, Dr. Keeler, on reworking Dr. Donaldson's records from the genetic point of view, finds that interaction between three genes or between three chromosomes on which these genes are markers, mainly control the antomical modifications and altered basic pattern of behavior found in the Wistar Albino rat. The three genes involved are coat-color genes. Increasing in order of their "domestication effects" they are: albino, piebald and non-agouti (black). The major effect on behavior is due to the non-agouti gene.

Rats that carry the black allele of agouti are "lazier" than their agouti relatives and they differ from them morphologically. There appears to be, furthermore, a reaction between the genes involved, so that they are somewhat additive in their effects on the metabolic and psychological changes in the rat.. Dr. Keeler's experimental matings of Wistar Albinos with Dr. King's gray Norways confirm these conclusions.

From these findings, domestication in the Wistar albino would appear not to be a long process of slow sifting out of a multitude of genes but rather a selection for "domestication" allels of a certain few important genes. Dr. Keeler went on to say that the basis of behavior produced by these genes may be modified in any individual by training. A rat carrying the "wild" agouti gene by constant handling can be made tame and gentle. But if an assortment of rats such as agouti and non-agouti (black) are raised to adulthood without training,

enormous differences in their behavior will be found.

This appears to be a capital discovery in advancing our knowledge of intellect and emotions. It has enormously important aspects in the handling of laboratory animals and in the domestication of livestock. Its theoretical implications on the genetics of human mental and emotional differences are only to be guessed. In absence of full published data it would be premature to risk predictions.

As Dr. Keeler pointed out, this whole discovery stems from Dr. Donaldson's life-long research on the morphology of rats that failed in his hands to solve the problem of domestication only because Dr. Donaldson's approach was morphological and Lamarckian rather than genetic. Dr. Donaldson believed that the behavior differences were due to brain modifications in the main, but he did not picture the brain changes of the Wistar albino as due to additive effect of coat color genes or of genes for which albino, piebald, and non-agouti are "markers."

Schweitzer's discussion of eponyms in the October JOURNAL suggests formidable catenations of names to designate the "civilizing" powers of the non-agouti region on a still unidentified chromosome, — "The Keeler-Donaldson-King Effect." Or Lamarck might be included too. Of even more practical value, we may have a new "fighting" word which can be said safely only with a smile: call a man a "non-agouti" only if you are ready to duck or hit first!

Research by Dr. W. C. Allee at the University of Chicago recently reported in *Science Digest* also seems on casual inspection to bear out Keeler's theory. —R. C.

◆

A Study of the Genetics of Twinning, in a Family with Quadruplets

ON September 26, 1880, were born in Switzerland a set of tetra-ovular quadruplets, Oscar, Bertha, Rosa, and Arthur Gehri, who are still living. They are normal, healthy people, bearing a familial resemblance to each other. They resemble each other more than they do their three half- and three full siblings, which Professor Otto Schlaginhaufen* regards as evidence that "the same environmental influences worked on the quadruplets synchronously, so that they were modified identically by them, which is not the case with single children born in different years and subjected to different influences." Even with their resemblance, the two men and two women differ in their occupation and temperaments. The monograph includes numerous photographs of the four from the age of two years to the age of sixty, constituting an interesting record of the growth and aging of healthy humans. The survival of all members of a quadruplet set to age sixty must be very unusual.

Schlaginhaufen has gone painstakingly into the genetics of twinning as expressed in the 18 pairs that in addition to the quadruplets, comprise the multiple births in the relatives of this group. His conclusions deserve reproducing:

> For each pair of twins—as for the quadruplets themselves—the genealogic position was marked on a pedigree chart and further investigation made as to the route by which the bearer of the trait, that is, the father or the mother of the multiple offspring, received the potentiality. Bonnavie's assumption, that this trait is determined by a simple recessive gene, was taken for granted, and further the opinion of Curtius and von Verschuer, that this gene in the homozygotic state manifests itself in male or female by the capacity to be the parent of identical or fraternal twins. The investigation sought above all to demonstrate twinning in the paternal and maternal collateral lines of each parent of twins. Of 18 cases it could be demonstrated in both paternal and maternal in eight, in only paternal or maternal in ten.
>
> The mother of the quadruplets has twinning seven times in the paternal collateral lines and five times in the maternal, and she is furthermore the maternal grandmother of two pairs of twins. She is without doubt a homozygotic bearer of the trait. For the father of the quadruplets it could only be shown that he is the son of a mother who was herself a twin, and that only one pair of twins is found in his maternal collateral lines together with the descendents of his siblings.

RAMSAY SPILLMAN, M.D.

*Die Vierlingsgeschwister Gehri und ihr Verwandschaftskries. Pp. 90 + 7 plates and 11 pedigree charts. A separate from the *Archiv der Julius Klaus-Stiftung für Vererbungsforschung, Sozialanthropologie und Rassenhygiene,* Band XV, Heft 3/4. (University of Zürich.)

CHANGE IN HAIR COLOR WITH AGE

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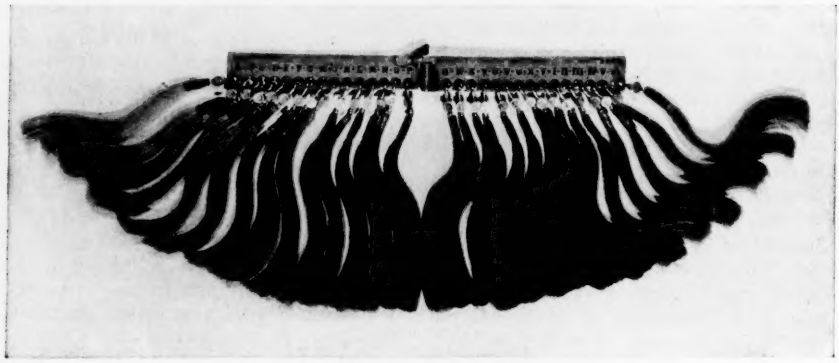

HAIR-COLOR CHART

Figure 9

The Fischer-Saller Hair Chart used in this study. On the opposite side of the metal bar is inscribed th following: *39 Haarfarbentafel nach Fischer-Saller. Hersteller: (?). Berger, Kiel, Holtenaustr. 27.* There are 24 grades of hair in the brown series on the left, lettered from *A* to *Y*. The six grades of red hair are at the right; identified by Roman numerals I-VI.

IT is generally known that hair color darkens with age. A child with light brown hair at six may have medium brown hair at 16 and dark brown hair at 26. The literature on this subject is meager, general, and as far as known to the author, never quantitative.* The present study deals with a longitudinal series of growing children measured annually for ten years in Holland, Michigan. The series consists of 220 males and 194 females ranging in age from 6 to 18. All are of 100% Dutch stock, the parents or grandparents of each child having been born in the Netherlands. For this study the origin of the parental stock in the Netherlands was not considered. However, the 414 children are relatively homogeneous. The children were measured each year in the month of November and their hair color was matched with the Fischer-Saller Haarfarbentafel (Figure 9). On this scale the samples run from *A*, a very light blond, to *Y*, a pure black, but the letter I is omitted on the scale to avoid confusion with the Roman Numeral I in the red section. Red hair is considered separately on the scale with Roman Numerals I to VI.

The matching was done in as bright daylight as possible. In each case the hair to be matched was selected at the back of the head because in that region it is generally darker and not so affected by bleaching. It was noted during this study that dirty, oily, hair may be as much as one or more units darker than clean hair, and also that long hair is easier to match than short hair.

In making the calculations, the letters *A* to *Y* were given numbers, so that an average figure might be obtained for each age. Thus *A* was given the number 1; *B*, 2; etc.

In the second column of Table I is

*See bibliography 2 to 6.

given the average hair color of children for a given age. This shows how much darker the hair for each age is than the preceding one. Thus, the average of 80 six-year-old children was 5.5, which is half way between *E* and *F* on the scale, 178 children seven years old averaged 6.4 and the 224 children eight years old averaged 7.6, etc. It will be noticed that for each age the hair seems to be approximately one unit darker than the preceding age.

The mean hair color for all observations on these Dutch White children was 11.4, which corresponds with letter *L* on the chart and the mean age was 12.5 years. The correlation coefficient of hair color with age was .526 ± .009.

In Table I the distributions are also listed according to sex. The males appear to have slightly lighter hair than the females; however, the difference does not appear to be significant. The correlation coefficient for males was .541 ± .012 and for females .506 ± .019.

Of the 414 individuals listed for this survey, 17 had red hair, or 4.1%. This percentage is a trifle higher than an average based on 478,976 Dutch people examined by Bolk and retabulated by Conitzer, who found that 2.45% had red hair. In a table summarizing 63 studies showing the incidence of red hair, Conitzer[1] found that the percentages range from less than 1% to 6.05% of the population. Thus our figure of 4.1% seems typical of North European stocks. On the Fischer-Saller scale, red hairs are numbered I to VI and progress from a brilliant red to a light red color, which might readily be confused with shades of light brown. The correlation of red hair with age gives a negative coefficient of .351 ± .054.

Red hair on the Fischer-Saller scale is numbered I to VI from dark to light in contrast with the other shades. For this reason the correlation is negative. This means that red becomes darker with age, as is true for the other hair colors.

Summary

Data on Dutch White children from Holland, Michigan, show that head hair becomes darker by almost one unit on the Fischer-Saller scale with each year of age for the ages 6 to 18. No significant sex differences were to be noted.

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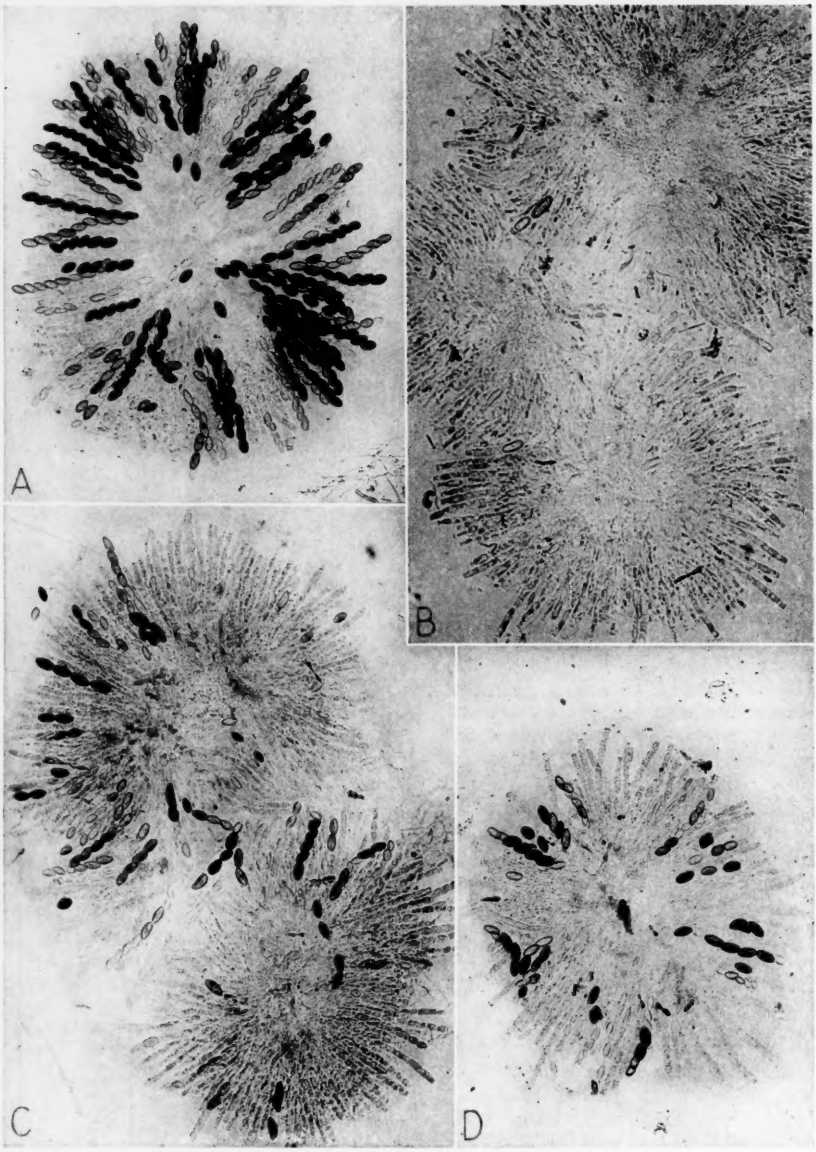
TABLE I. Mean hair color for Dutch White children for each age from 6 to 18. The number of cases is made up of 414 individuals re-examined yearly over a 10 year period.

			Males		Females	
Age	Mean hair color	Number of cases	Hair color	Number of cases	Hair color	Number of cases
6	5.5	80	5.2	48	5.8	32
7	6.4	178	6.4	103	6.6	75
8	7.6	224	7.5	122	7.7	102
9	8.7	218	8.7	123	8.7	95
10	9.2	246	9.0	134	9.4	112
11	10.2	267	10.1	144	10.5	123
12	11.1	285	11.0	155	11.3	130
13	11.9	304	11.7	165	12.1	139
14	12.5	307	12.4	167	12.7	140
15	13.5	302	13.6	167	13.3	135
16	14.3	219	14.3	117	14.3	102
17	15.2	128	15.4	65	14.9	63
18	15.7	43	16.2	29	14.6	14



COMPARATIVE FERTILITY OF WILD-TYPE CULTURES AND OF THREE X-RAY MUTANTS

Figure 10

A—A cluster of asci removed from a perithecium produced by mating two strains of normal fertility. Many of the asci contain eight ripe spores and there is a background of asci containing no ripe spores at all. Occasional cases of segregating spore abortion and other irregularities occur. *B—Mutant X-12* mated with normal wild-type. None of the asci in the three peritheceia shown in the photograph produced ripe ascospores, although a few ripe spores were obtained from the mating. *C—Mutant X-17* mated with normal wild-type. Two and

X-RAY AND ULTRA-VIOLET INDUCED MUTATIONS IN NEUROSPORA*

I. X-Ray Mutations

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STADLER and Sprague[7] compared the genetic changes induced in maize by ultra-violet and x-radiation. They found that x-rays produced translocations, inversions, deficiencies, and apparent point mutations. The genetic changes induced by treatment with ultra-violet light did not include either translocations or inversions, but were principally deletions and apparent point mutations. Swanson[8] confirmed Stadler and Sprague's findings cytologically by showing that when chromosomes in the pollen tube of *Tradescantia* are irradiated, x-rays induce translocations, while ultra-violet rays induce terminal deficiencies.

The present study was undertaken at Dr. Stadler's suggestion and carried out under his direction at the Genetics Laboratory of the University of Missouri. We are much indebted to Dr. Stadler and Dr. Fred Uber for their assistance and helpful suggestions.

The uninucleate spermatia of *N. crassa* were treated both with x-rays and ultra-violet rays. X-ray treatment induced both gene mutations and chromosomal abberration, one of which was specifically identified as an inversion. Ultra-violet treatment induced gene mutations and many of the ultra-violet treated variants were degenerate phenotypes which did not yield to genetical analysis. No chromosomal aberrations were found among the ultra-violet treated variants.

Our experiments were specifically designed to determine if variations are induced by ultra-violet and x-rays and to test these variations as to their genic and chromosomal nature. Single mononucleate spores from freshly isolated pedigreed cultures were treated and compared with an adequate number of controls. In spite of the abundant work in the induction of variation in the fungi, experiments have not been designed which prove (1) that the agent used was actually the primary cause of the variation and (2) that the variation induced was either genic or chromosomal in nature. Experiments on induced mutation in which multinucleate spores or polysporous transfers were used are open to the criticism that the particular agent might simply have separated mutations already present in a heterokaryon. That this criticism is to the point, is proved by the fact that single ascospore cultures of *Neurospora* which are stored or carried in culture for a few months almost invariably become heterokaryotic due to spontaneous mutation. Manipulations of stored fungus cultures, involving nothing more than single conidial transfers separate such a heterokaryon and

LEGEND TO FIGURE 10—Continued

four-spored asci appear along with asci containing odd numbers of ripe spores and misshapen spores against a dense background of asci in which no ripe spores are produced. The regular arrangement of ripe and aborted spores in the ascus shows that abortion is determined at meiosis. *D—Mutant X-2 (curly-fluffy)* mated with normal wild-type. Two and four-spored asci along with some irregular asci appear against a background of totally aborted asci. Regular arrangement of aborted and ripe spores is the rule. In all these photographs the black spores are fully ripe while the grey spores are not ripe and the spores which are smaller and lighter in color are typical aborted spores. In many asci, total abortion of the ascus occurs before spore formation has been initiated.

*With the support of a grant from the Penrose Fund of the American Philosophical Society, Philadelphia.

give any preceding treatment the false appearance of having been responsible for inducing the mutation.

Spermatia of Neurospora Crassa

Neurospora crassa produces three kinds of spores (1) binucleate ascospores, (2) multinucleate conidia, and (3) uninucleate spermatia. The conidia are variable in size and contain from a few to many dozens of nuclei. This multinucleate character makes them undesirable for use in radiation experiments.

The uninucleate spermatia (Dodge,[1] Zickler[10]) are ideally adapted to radiation experiments. Unlike standard spores, the spermatia have extremely thin walls. This adaptation fits them for their primary function of fusing with the trichogyne of the female sex organ. They are rather small, varying from three to five microns in diameter and are produced abundantly by either plus or minus sexes. In these thin-walled spermatia, the amount of radiation absorbed by structures other than the nucleus is reduced to a minimum. They begin to germinate on ordinary medium after a delay of about forty hours. We obtained spermatia from the *fluffy,* non-conidial variant of *N. crassa.* This non-conidial *fluffy* mutant produces only spermatia. Wetting down the *fluffy* culture with sterile water after it is about ten days old, results in an abundant production of spermatia, 24 hours later.

Treatment

Difco beef extract nutrient agar was filtered through paper so that the small particles ordinarily present would not be confused with spermatia. Single spermatia were placed in marked positions on the agar by means of the manipulator which we regularly use in ascospore isolations. A small glass rod was drawn out to a thin thread and broken off. The end of this thread was then melted to produce a tiny terminal ball. The spermatia were moved about in the film of water between the surface of the agar and the glass ball.

Each petri dish was divided into four sections and, by means of a lead shield, three of the quarters of the plate were given different amounts of radiation, while the fourth quarter functioned as a control. During the treatment, the petri dish cover was replaced by a sheet of sterile cellophane held in a crochet hoop. This protected the agar from dust contamination and the lead plates were placed above it.

Twenty-four hours after treatment, when some of the spermatia were beginning to show signs of germinating, each small piece of agar holding a single spermatium was transferred to a small test tube containing potato dextrose agar. About three or four days later, aerial hyphae appeared in the tubes containing viable spermatia. All the spermatia were planted in tubes, in spite of the fact that after 24 hours only a few usually gave indications of viability.

In a series of preliminary experiments, it was found that a considerable number of spermatia survived 40 minutes' radiation equivalent to 22,000 *r* units, while extremely few survived twice that dosage. Two treatments of 25 and 40 minutes each, amounting to 13,750 and 22,000 *r* units respectively were used in the induced mutation experiments. The results are tabulated as follows:

TREATED

	13,750 *r* units (25′)		
Germinated	variant	8 (16%)	63%
	non-variant	51 (84%)	
Failed to Germinate		40	37%
	22,000 *r* units (40′)		
Germinated	variant	12 (33%)	44%
	non-variant	37 (87%)	
Failed to Germinate		62	56%

CONTROLS

	13,750 r	22,500 *r*
Germinated	50 (84%)	77 (83%)
Failed to germinate	11 (16%)	16 (17%)
Variants	None	None

Classification of Variants

Fluffy is one of the *Neurospora* mutants easily affected by modifying genes. Therefore, *fluffy* cultures are very likely to show the presence of new mutations induced bv treatment. The classifications "variant" and "non-variant" were

made by inspection of the culture grown from the treated spermatia. The cultures from the control spermatia were similarly inspected. The validity of the classification of the x-ray variants was tested by making subcultures in triplicate from each of the variant cultures, as well as from the treated non-variant cultures. These were all inspected to determine if the characteristic difference (or lack of it) had been transmitted vegetatively. Ten of the 20 x-ray variants proved to be completely stable, but the other variants were unstable on serial transfer.

Tests for Gene Mutation

Most of the stable forms were double mutants, carrying the *fluffy* gene (*F*), as well as the new mutant gene (*X*). These double mutants (*FX*) were mated to wild-type tester strains (*fx*). Segregation in the ascus resulted in four genotypes:

1. the double mutant (FX)
2. the non-mutant wild-type (fx)
3. the original fluffy form (Fx)
4. the new mutant in the pure form (fX).

Segregation at meiosis of the factors induced by treatment was conclusive proof of their genic nature. *Fluffy* cultures lack the normal monilioid conidia indicating that this gene suppresses the mechanism which is responsible for conidium formation. All the mutant cultures (containing *fluffy*) were likewise non-conidial, although many of the single mutants (not *fluffy*) were conidial.

Gene Mutations

Dissection of asci produced by mating mutants *X-3, X8, X-11, X-16,* and *X-24* by wild-type revealed that they were apparently uncomplicated cases of gene mutations. Treatment had induced a single mutation in the *fluffy* form. The variant cultures were double mutants (*fluffy-"induced"*), which when mated to wild-type produced four types of progeny.

Mutant X-3. (*Coral fluffy*). This double mutant had an even growth at the top of the culture and a coral colored exudate. *Coral* was found to be 25 units from the centromere and probably not linked to *fluffy*. Mating the double mutant, *coral-fluffy,* to wild-type resulted in (1) *coral-fluffy,* (2) wild-type, (3) *coral,* and (4) *fluffy*. Purified *coral,* the single mutant, produced deformed, catenulate conidia, not dichotomously branched.

Mutant X-8. Fan-fluffy. The double mutant had fan-wise spreading hyphae, located about 13 units from the centromere and not linked to *fluffy*.

Mutant X-11. Brown-fluffy. The double mutant had bunched mycelia with brown rings in the substrate.

Mutant *X-16. Colonial-fluffy*. The double mutant had short hyphae and a colonial type of growth (like *Penicillium*) differing from the ordinary exploratory Neurospora habit. The single mutant, *colonial,* was characterized by light-colored, monilioid conidia and the cultural growth was also colonial in habit.

Mutant X-24. Bunched-fluffy. The double mutant had poor vigor and produced mycelia in bunches along the side of the tube.

A Heterokaryon

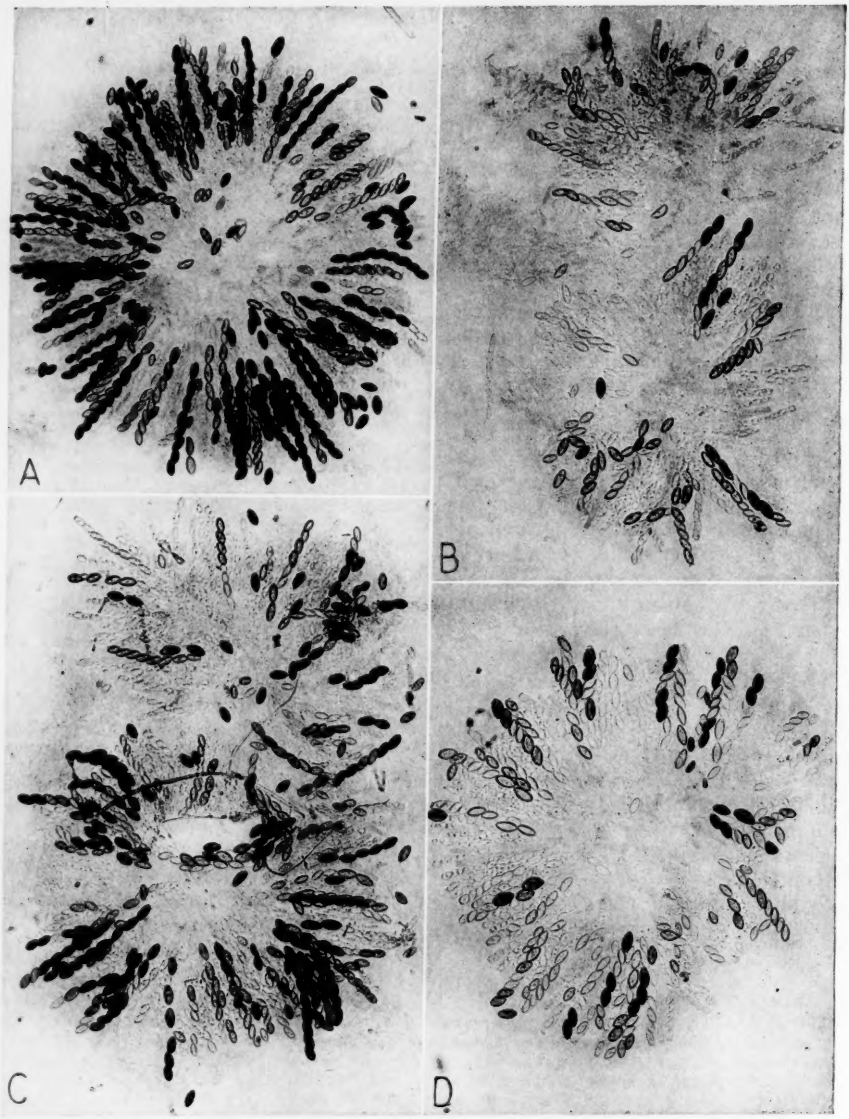
Mutant X-23. Scant-fluffy produced scantier growth than standard *fluffy*. The culture obtained from the original spermatium was heterokaryotic. This heterokaryosis might be due to reverse mutations, to transfer of more than one spermatium into the original tube, or the first spermatium might have been binucleate or possessed split chromosomes. Mating *X-23, scant-fluffy* with wild-type, produced two types of asci. In one type of ascus a mutant gene was segregated from wild-type in a regular manner. The other type of ascus carried only wild-type and standard *fluffy*.

A Triple Mutant

Mutant X-5. Feathery-black-fluffy. Each nucleus in the thallus carried two induced mutant genes in addition to the original *fluffy* gene. When mated to wild-type, three clearly different genotypes were segregated at the reduction of each zygote nucleus, giving a typical tri-hybrid ratio. One of the new mutants produced rich orange conidia and the other a dark substrate.

Phenotypic Instability Due to Reverse Mutation

Some of the mutant cultures grown from single treated uninucleate spermatia were not stable when subcultured. In some cases this instability had its origin in reverse mutation of the induced mutant gene. The haploid nuclei produced by the continued division of the original mutant nucleus are commingled in a common cytoplasm. In a mutant of low vigor and slow growth, an occasional reverse mutation may produce nuclei more successful in competition than their progenitor and these reversion nuclei multiply more rapidly than the original mutant nuclei. If the reverse mutation occurs before the culture becomes so old that the medium is staled, the effect is apparent phenotypically almost at once. Because of the fact that the thallus is practically structureless vigorous, reversion nuclei are potentially capable of attaining supremacy. In a higher plant, a reverse mutation will usually



SEGREGATION OF ABORTION IN THE PROGENCY OF *CURLY-FLUFFY* BY WILD-TYPE

Figure 11

A and *B* show the types of asci produced when the ascospores from a four-spored ascus such as those shown in Figure 10*D* were mated to a normal wild-type individual. The particular ascus is No. 559, which contained four ripe spores. Spores 1 and 2, and 5 and 6 aborted, while spores 3 and 4 and 7 and 8 were ripe. The four ripe spores germinated and produced cultures. Spore 4 carried the double mutant *curly-fluffy*, while spore 8 was normal wild-type. *A* shows the normal fertility produced by mating the wild-type culture from spore 8 to wild-type, while, *B* shows the characteristic type of abortion resulting from mating the *curly-fluffy* culture obtained from spore 4 with a normal wild-type individual. *C* and *D* show the types of asci obtained by

not be phenotypically apparent because of diploidy. Moreover, if it is isolated in an inflexible structure, even a dominant progressive mutation will not significantly alter the course of development of the plant as a whole. However, in the fungi (many of which are practically coenocytic) transfer of a portion of a thallus containing large numbers of reversion nuclei will produce a subculture differing in appearance from the original, for the haploid reversion nuclei can readily attain supremacy under these conditions (Lindegren[4]). This type of unstable culture has been studied in considerable detail and already reported in the case of the *tan* mutation, Lindegren.[5]

Semi-lethal Mutants

Mutants X-18, X-20, and *X-22,* were semi-lethal gene mutations.

Mutant X-18. The original culture died out in subculture, indicating its poor vigor, but a mating of the first culture to the wild-type tester produced asci. Eight apparently ripe spores were found in each ascus, but only four germinated. The four non-viable spores carried the semi-lethal mutant gene. However, when a large number of asci were dissected, a few mutant cultures were obtained. Tests were made to distinguish this condition from that produced by the presence of an inversion. Semi-lethal genes can be distinguished from inversions by cross-breeding the mycelia obtained from the four viable spores found in a single ascus. Such matings produced asci in which all eight spores were viable, while a similar mating in the case of an inversion, produces four viable and four non-viable spores.

Mutant X-20. The original spermatial culture reverted to standard *fluffy,* when subcultured, indicating that a reverse mutation had occurred and that the semi-lethal was associated with the original genotype from which it was derived in a heterokaryon. When the original culture was mated to wild-type, asci containing eight apparently ripe spores were obtained. These spores all germinated on heat treatment, but only four produced cultures. Twenty-four asci were analyzed and the mutant was not recovered in any case. Evidently this semi-lethal cannot produce a viable ascospore culture. When the four viable spores from an ascus are mated to each other, eight-spored asci are found and all eight spores produce cultures.

Mutant X-22. This culture reverted to standard *fluffy* on serial subculture and usually produced only four viable ascospores. It was not, however, analyzed so extensively as the preceding two semi-lethals.

Degenerate Phenotype

Mutant X-25. Degenerate-fluffy. The double mutant produced extremely thin mycelial growth with a brownish color and the substrate became tan. The original spermatial culture was mated to wild-type and six asci were dissected. These are analyzed below.*

Although no viable culture was recovered carrying the degenerate phenotype, the distribution of abortion and failure of some spores to germinate suggest the presence of the degenerate gene. Ascus No. 6 which differed from the other five asci in producing eight viable ascospores, indicates that the original culture was already heterokaryotic for degenerate and wild-type.

The first three subcultures from the original Mutant *X-25* were each weaker than the preceding one, but the fourth subculture reverted to standard *fluffy.* Spermatia were selected from this last culture to determine if it were heterokaryotic. Nine of the spermatia grew and eight produced standard *fluffy* cultures, while one produced the degenerate phenotype. This degenerate phenotype was mated to wild-type and six asci analyzed. All produced four *fluffy* and four wild-

LEGEND TO FIGURE 11—Continued

mating the four spores from ascus 582 by normally fertile wild-type. In ascus 582, spores 1 and 2, 3 and 4 were ripe while spores 5 and 6, 7 and 8 were aborted. Spores 1 and 2 were *curly-fluffy,* while spores 3 and 4 carried the *curly* gene alone. *C* shows result of mating spore 4 (*curly*) with normal wild-type. A few eight-spored asci are obtained with some two- and four-spored asci and a considerable background of total abortion. *D* shows the result of mating spore 2 (*curly-fluffy*) with normally fertile wild-type. Two- and four-spored asci are obtained with a considerable background of total abortion.

*Ascospores	Ascus 1	Ascus 2	Ascus 3	Ascus 4	Ascus 5	Ascus 6
1	wild	aborted	aborted	wild	fluffy	wild
2	wild	aborted	aborted	fluffy	aborted	wild
3	not germ	not germ	aborted	wild	fluffy	fluffy
4	not germ	not germ	aborted	fluffy	aborted	fluffy
5	not germ	wild	fluffy	fluffy	wild	wild
6	not germ	wild	fluffy		not germ	wild
7	wild	wild	not germ	not germ	wild	fluffy
8		wild	not germ	not germ	wild	

type ascospores, indicating that the degenerate nuclei had undergone reverse mutation before the mating was made and that the standard *fluffy* nuclei were more successful in competition at zygote formation than those carrying the degenerate gene.

Tests for Fertility

In addition to cultural variation, about half of the x-ray variants gave evidence of diminished fertility. This phenomenon may be due to induced chromosomal aberration. All the variant cultures, 37 of the non-variant cultures originating from spermatia which had received 22,000 r units (40′), and 22 of the control cultures were tested for fertility. Progenies were grown from all the variant matings, from 21 of the treated non-variant matings, and from eight of the control matings.*

In the ordinary case of normal fertility (Figure 10 *A*). many of the asci contain eight ripe spores. A few asci containing both ripe and aborted spores are also present. However, even in normal fertility, there is always a large number of asci in each perithecium containing no ripe spores and in which all eight spores have been aborted. In the most fertile strains now available, all eight spores are aborted in variable numbers of asci, ranging from two-thirds or more to less than one-half.

Diminished fertility is manifested in a variety of ways: (1) *Partial abortion* (Figure 10, *C* and *D*). Most of the asci contain no ripe spores at all and eight-spored asci are rare. Usually even numbers of spores ripen in each ascus with two- and four-spored asci conspicuously present, but rarely one-, three-, five-, and seven-spored asci are also found. (2) *Almost complete abortion* (Figure 10, *B*). The asci contain almost exclusively aborted spores. Only a few ascospores ripen in an occasional perithecium. (3) *Empty perithecia.* Perithecia are produced, but without any contents, indicating that no young asci have been initiated.

Interpretation of Sterility

a. Translocation

In crosses between the most fertile strains available a large number of asci are found in which all eight spores are aborted. This makes it difficult to detect translocations, because a single translocation should produce eight aborted spores in about half of the asci, while the rest of the asci should contain eight viable spores each. The customary (apparently normal) background of aborted asci is not constant with regard to the percentage of aborted and full asci. It even varies considerably from perithecium to perithecium.

b. Deletions and Deficiencies

If treatment of the original spermatium produced a deletion or a deficiency, the spermatium would not germinate.

c. Inversions

The class of sterility designated as *partial abortion* is probably due to an inversion. If *no* crossing over occurs within the inverted region, a zygote heterozygous for a single inversion should produce eight viable ascospores, four carrying the inversion and four without it. If a single crossover occurs *within* the inverted region, the ascus should produce two viable normal ascospores, two viable ascopores carrying the inversion and four non-viable ascospores carrying the duplication-deficiency complex.

d. Gene Mutations Causing Sterility

Empty perithecia may be due to gene mutations. This can not be tested, however, because of the complete absence of any sexual progenies.

Analysis of Partial Abortion

Mutant X-2. Curly-fluffy. The myce-

	Total No. of cultures	Tested for fertility	Showed Diminished Fertility
*X-ray variants ..... 25 & 40′	20	20	9
Treated non-variants ..... (40′)	37	37 (21 analyzed)	0
Controls non-variants	77	22 (8 analyzed)	0

lium was spirally curled and twisted. The perithecia produced on mating to wild-type were characterized by varying degrees of ascospore abortion. A typical perithecium is shown in Figure 10*D*. Counts were made from different numbers of asci showing different arrangements of aborted and ripe spores. In the tabulation below, R—indicates ripe, and a—indicates aborted:

Spore pairs	TYPE OF ASCUS											
1&2	R	R	R	a	R	R	a	R	a	a	a	a
3&4	R	R	a	a	R	a	R	a	R	a	a	a
5&6	R	R	R	R	a	R	R	a	a	a	R	a
7&8	R	a	R	R	a	a	a	R	R	R	a	a
No.	5	3	3	10	11	28	24	11	15	2	2	many

99 4-spored asci

Cultures were grown from 19 asci and classification of the progeny yielded the following ratios: *wild-type*, 34; *curly-fluffy*, 16; *curly*, 8; and *fluffy*, 4. The original combinations were *wild-type* and *curly-fluffy*. Therefore, *curly* is linked to *fluffy* about 16 units away. Some factor is apparently lethal to half the *fluffy* genotypes. The following tabulation shows the arrangement of spores in 13 asci. "Unripe" means that the spores were olive-green rather than the black color which indicates ripeness. Unripe spores practically never germinate. "Ripe" means that the spores were ripe as indicated by the black color, but nevertheless did not germinate when heat-treated. The phenotypes of the germinated spores are indicated by gene symbols:*

The mycelia obtained from the first seven asci (first four columns) were mated to wild-type and the clusters of asci obtained from the crushed perithecia were photographed, (Figure 11). All the wild-type progeny, when outcrossed, produced eight-spored asci in as great abundance as any of the *fluffy* fertile strains. *Curly-fluffy* by wild-type produced predominantly two- and four-spored asci (Figure 11 *B* and *D*). Curly by wild-type (Figure 11*C*) produced ocassionally six- and eight-spored asci, but with large numbers of the two- and four-spored asci as well. This difference in the fertility of the *curly* and the *curly-fluffy* segregants, suggests other complications which will be studied in detail later.

Mutant X-17. Ivory fluffy. The mycelium produced puffy, short ends with

*Spore pairs	TYPE OF ASCUS								
1&2	ab	ab	unripe	Cu-F	ab	wild	wild	wild	ab
3&4	wild	wild	Cu-F	Cu	wild	wild	wild	ab	ab
5&6	Cu-F	ab	ab	ab	ab	ab	ripe	F	ab
7&8	ab	Cu-F	wild	ab	wild	ab	ripe	ab	wild
	2	2	1	2	4	1	1	1	1

TABLE I.—Classification of X-Ray Mutants

	Subculture	22,000 r. Culture No.	13,750 r. Culture No.
Simple gene mutations	constant	X-3, X-24	X-8, X-11, X-16
Heterokaryon	constant	X-23	------
Triple mutant	constant	X-5	------
Semi-lethal mutations	20, 22 reverting 18 died	X-20, X-22	X-18
Degenerate phenotype	reverting	X-25	------
Partial abortion	constant	X-2, X-17	------
Almost complete abortion	4 constant 19, 21 reverting 12 weaker	X-4, X-21 X-19	 X-12
Empty perithecia	reverting	------	X-7, X-9, X-13

Probably not mutants—X-6 (40′), X-10, X-14, and X-15 (25′) were classified as mutants in first inspection, but subsequent transplants were all identical with standard fluffy, so they do not appear in the table. Only non-mutant progeny were obtained by making them with wild-type. Total number of cultures, 24, serial numbers X-2 to X-25.

an even rim of growth at the top of the culture and an ivory color. The types of asci produced by mating *ivory-fluffy* by wild-type are shown in Figure 10 *C*. Progeny grown from this mating showed varying degrees of fertility. Some produced indurated asci like those found by Dodge[2] in matings of cultures obtained from ascospores of *N. tetrasperma* which had been treated with x-rays by Uber and Goddard[9]. Similar indurated asci have been observed in matings of spontaneous mutants of *N. crassa* by Lindegren and Scott.[6]

Almost Complete Abortion

Mutants X-4, X-12, X-19, and *X-21* produced occasional ascospores when mated to wild-type. Numerous matings were made of these mycelia to normally fertile wild-type. All these matings regularly produced mycelia which only rarely contained ascospores. Figure 10 *B* shows the asci produced by mating *Mutant X-12* with a normally fertile wild-type. This condition persisted in the cultures which reverted to standard *fluffy*. If the phenotype of the culture were due to a mutant gene, and the sterility to a chromosomal aberration, the reverse mutation of this gene did not restore the original fertility.

Empty Perithecia

Mutants X-7, X-9, and *X-13,* produced only empty perithecia, when mated to normal wild-type. They all reverted to standard *fluffy* on subculture without improvement in fertility. The distinguishing characteristic of the variants characterized by extremely diminished fertility is their low vigor and their marked tendency to revert to standard *fluffy* without improvement in fertility.

Summary

X-ray treatment of uninucleate spores of *Neurospora crassa* induced gene mutations. Abortion of ascospores also occurred in the progeny of about half of the mutants and one such case was specifically identified as an inversion.

Many of the cultures in which mutation was induced became heterokaryotic by reverse mutation.

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No Social Newtons

"Mankind in the aggregate is, I suggest, ruled by laws or principles of behavior as immutable as those which guide the performance of the molecules of air he breathes. To be sure, the laws of social behavior have not proved as easy to discern as have those of the material world. Newton, single-handed, was able to envisage and enunciate clearly the law which guides the planets in their courses. Faraday and Maxwell drew a correspondingly clear picture of the domain of electrical phenomena. But the world has still to rear its social Newtons and its political Faradays and Maxwells. Indeed, the task is so complex that one wonders whether these social and political discoverers, when found, may not prove to be groups of able investigators who have banded together to secure the increased power of carefully focussed endeavor — not individual human beings."—Dr. Frank B. Jewett, *Science News Letter.*

THE INHERITANCE OF EAR PITS IN SIX GENERATIONS OF A FAMILY

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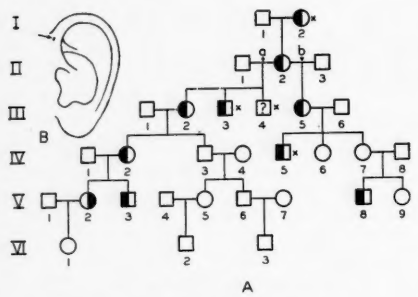
EAR pit (Fistula auris congenita) has received the attention of anatomists and geneticists over a long period, and within recent years several papers on the inheritance of the trait have appeared in the literature.

Kindred[2] described four generations of a family, some members of which exhibited fistulae. In a total of 38, ten individuals were affected, and from his observations he concluded, "Judging from the manner of its appearance, the marking is neither dominant nor recessive, but must fall into the intermediate doubtful class of incomplete dominance." Whitney[6] studied a family in which seven of 31 persons exhibited fistulae. In this group, Whitney stated that the presence of ear pits behaved as a simple dominant trait. Quelprud[4], in a recent study of a large family, found 17 affected individuals in a group of 150. Numerous others were listed as possible bearers of the trait. Included in Quelprud's report were data for several sets of twins in which one or both individuals were affected. The data in Quelprud's study point to the inheritance of Fistula auris congenita as an irregular or incomplete dominant. In the pedigrees presented by Kindred[2], Whitney[6], and Quelprud[4], it was shown that the fistulae might be present on one or both sides and, in the cases where it was unilateral, on either the right or left side. Persons of both sexes were affected, and the depth of the pit was found to vary from a shallow inconspicuous mark to a cyst-like formation from which an exudate appeared in some cases. The variation in extent of pit depth has led to considerable speculation as to the embryonic origin of the phenomenon. The work of Quelprud[4] and of Wood-Jones and I-Chuan[7] may be consulted for further information on this point.

Stiles[5] has reported further data on ear pits and recently McDonough[3] has studied them in identical twins. In the latter report it was shown that persons in whom the pit is absent may have pitted offspring. This has been observed by others as well.

The present author has had the opportunity to observe individuals of a family in which ear pits occur with relatively high frequency, and has studied all but four of the descendants of an affected woman for five generations. The trait was said to have appeared in the family of this woman (Figure 12*A:* I-2) for several generations, but no adequate records of its occurrence were found beyond the first generation shown in the chart. The four persons not seen by the writer are indicated by 'X' in the pedigree chart. However, records were available for three of the four (I-2; III-3; and IV-5), but no information was found for the remaining one (III-4), although, according to another member of the group, he was thought to have been affected also. This family is of particular interest since the second woman (II-2) with the trait married twice and some of the descendants of each marriage exhibited the pit. No individual was found with pits in the helices of both ears, and all but one (V-2) bore the mark on the left ear. In every case the pit was shallow, about one to 1.5 mm. in depth and usually oval in shape with a long diameter of one to two mm. The location of the pit with relation to the helix of the ear is shown in Figure 12*B;* no deviations from this location were observed. One instance was found in which the pit disappeared for a generation but reappeared in the son (V-8) of two normal parents. In this case, no person in the family of the male parent was known to have the anomaly. The present pedigree shows



A

PITS IN ONE EAR ONLY
Figure 12

A—Pedigree chart of the group discussed in the text. Shaded half in affected individuals shows the side on which the ear pit occurred. Individuals not observed by the author are marked with an "*X*" (see text). In the second generation, *a* indicates first marriage, *b* second marriage. *B*—Arrow points to location of ear pit in all persons observed.

also that an affected individual married to a normal person may have both normal and pitted offspring. In this fraternity the pit appears to be transmitted by women only. This is apparently only a chance occurrence, however, since it has been shown previously that either sex may transmit the character. In the group under consideration two affected males died in early infancy or during childhood (III-3 and IV-5 on the chart). Two other affected males are living but have no offspring.

With the exception that in this family the trait has not been transmitted by males, the data support the findings of others and seem to indicate that the trait is incompletely dominant and quite variable in its occurrence. Further than this the data yield no information as to the action of the factors responsible for the peculiar behavior of this trait in inheritance. McDonough[3] has suggested that the factor tending to produce the condition may be more potent in certain genotypes than in others and that pre-natal environment may affect the time of gene action and thus the nature and presence or absence of pits.

In connection with the foregoing discussion it is of interest to note that another ear character — a sinus in the lobe of the ear — has recently been reported by Edmonds and Keeler[1] and found to be inherited as an incomplete dominant also.

Summary

Data on inheritance of Fistula auris congenita in six generations of a family have been presented. The observations and conclusions reported in this paper are in agreement with those of others with reference to the character and location of the trait and its manner of inheritance as an incomplete dominant.

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✦

THE MEDICAL SCHOOLS TAKE UP GENETICS

PROBABLY most readers of this review will remember Knight Dunlap's "Antidotes for Superstitions Concerning Human Heredity" in the *Scientific Monthly* for September 1940, and how artistically Messrs. Clyde E. Keeler and Robert Cook in this Journal for November 1940, refuted Dr. Dunlap's ex cathedra and pontificial utterances in a field in which he is obviously one of the most poorly qualified of witnesses.

The reader would do well to overhaul the volume for these two treatises, as a preparation for an enhanced appreciation of Dr. Snyder's lectures which were presented to the medical schools of Duke

University, Wake Forest College, and the University of North Carolina.* Dr. Snyder remarks "It is obviously impossible to give an accurate account of the basic principles of genetics in a short series of lectures on medical genetics. These lectures have dealt strictly with medical conditions and their practical applications. Nevertheless, an attempt has been made to outline the more important kinds of hereditary behavior in such a way as to make them understandable."

One of the most prominent and effective public health workers of the Victorian age in England was Sir Benjamin Ward Richardson, whose writings show that he took very little stock in the new teaching that the typhoid bacillus was the cause of typhoid fever. The reviewer is in a position to testify that most of the established medical profession which he has sampled, stand in the same relation to genetics that an earlier generation of physicians stood in relation to bacteriology. An occasional individual holds in contempt genetic findings derived from rodents, because he looks upon the lord of creation as something special and not subject to the laws that hold for the lower animals. That the lord of creation does not always live up to this respectful estimate in reference, for example, to monogamy being an attribute of the highest social differentiation, is attested by one of the most tangible applications of medical genetics being devoted to inherited blood-grouping as evidence in cases of disputed paternity. In fact, the author of the volume under consideration has written a book entitled *Blood Grouping in Clinical and Legal Medicine*, a subject to which he devotes a lecture here, in which there is highly useful material for any physician who may be consulted on this most ancient and vexatious of problems.

In as brief a presentation of so important a subject as medical genetics, there is necessarily much that has to be stated in rather a peremptory fashion, leaving the reader in the position of Mr. Midshipman Easy, wishing to stay and argue the point with him. It will be a new conception to many medical men that a good case has been made out for an hereditary basis for psoriasis: "The etiology is unknown, some considering it a genetic susceptibility to a parasitic fungus, others holding that it is allergic or toxic. Whatever the etiologic basis, it seems to be genetic. There is a dominant form in some families, a recessive form in others, indistinguishable clinically."

Unquestionably a proper genetic conception of susceptibility to disease has been retarded in the medical profession by four factors: (1) the available family history has not always been thoroughly studied, (2) such records as have been obtained have not always had sound genetic knowledge brought to bear on them, (3) it is exceptional for an individual to know anything about his family medical history as far as two generations back, and (4) the medico-legal importance of blood groups bears witness to the fact that not infrequently one person is the ancestor of record and another is the one in fact. It is not entirely out of order to mention a fifth: opposing conclusions on the same evidence are sometimes drawn, witness the controversy between Maude Slye and C. C. Little on the inheritance of cancer in Maude Slye's mice. With an average of say 25 years to a generation and reckoning genetics as a science only about 40 years old, (dating it from the rediscovery of Mendel's laws—Mendel's own discovery having been too far in advance of his age to make an imprint at the time), and with the difficulty of Homo sap. to view himself strictly objectively, perhaps the wonder is not that so little is known to date on human genetics, but that so much is known. This volume of lectures is important, not only for its content, but because it marks the development of a trend in medical education. The medical students who had the opportunity to attend these lectures will enter the practice of medicine with this advantage over their established colleagues out, say, twenty years: they have at least heard

*Snyder, Laurence H., Medical Genetics. Pp. 130 + viii. Cloth bound. $1.50. Duke University Press, Durham, N. C. 1941.

such words as autosomal, nondisjunction, penetrance, expressivity, under such auspices that they make the mental effort to digest them and not reject them as pits, which latter the reviewer regrets to testify that some of his own contemporaries do. It is a pleasure to note one exception to this stricture, however. A speaker observed before the New York Society of Medical Jurisprudence at the meeting of May 12, 1941, in the reviewer's hearing, "The more experience I get, the more I am impressed with the role of heredity in the etiology of disease." The speaker was Dr. James Ewing, whose name is one to conjure with in medicine.

There are other signs and portents that a change is in the air. In 1939 and 1940 the Woman's Medical College in Philadelphia held symposia on applied medical genetics. Concerning this the *Journal of the American Medical Association* reported that "although a number of medical schools offer occasional lectures on this subject, this series of lectures, in continuation of a group presented last year, is believed to be the first symposium on this subject sponsored by a medical school in this country. The lectures outlined last year were printed in book form under the title *Medical Genetics and Eugenics.*" Even more recently we have the announcement of the establishment of a department of human heredity by the University of Michigan. It is heartily to be wished that this department and these other awakenings will produce investigators combining adequate training in both medicine and genetics who will be capable of directing similar departments in other institutions. For at this time the woeful shortage of medical personnel who can tell when to expect a 3:1 ratio and when a 1:1 ratio is downright distressing.

And after the investigators and teachers have been trained will come the problem of how this information is to be imparted. The medical curriculum has already reached a stage of being overstuffed to the point of rupture. Any medical school is doing exceedingly well by genetics, under today's circumstances, in devoting a series of didactic lectures to it. The physicians of the future are going to have to know something about genetics, and where they must needs get it is in the arts and sciences required for entry to medical school. Mature men today will still live to see the time when preparation for the study of medicine without a sound grounding in genetics will be as unthinkable as preparation for medicine without biology would be today. When that time arrives, Dr. Snyder will be looked upon as one of the major early prophets, and he should not lack for honor in his own land. In many ways Duke University has given evidence of being one of our more forward-looking institutions of education. That it has published this volume of lectures calls for further citation for merit.

RAMSAY SPILLMAN, M.D.

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Albino Raccoons—A Genetic Opportunity

A pair of wild black raccoons which have produced five male albino offspring is reported by Mr. Raleigh Gregory, P. O. Box 125, Webser Springs, West Virginia. The male albinos have been produced over a period of four years, so that the possibility of a sex-linked inheritance is suggested.

Mr. Gregory is anxious to dispose of the parents and the albino offspring which range in age from six months to three years. Persons or institutions interested in purchasing the albinos should communicate with Mr. Gregory.

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